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## Civil and Structural Engineering

Assessment of Terminal Capacity

Monotonous and Cyclic Behavior

Highlights

Silty Sands of Three Hilly Areas

Development of Dam Construction

Discovering Thoughts, Inventing Future

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## Assessment of Terminal Capacity for Cargo Handling in Lagos Airport, Nigeria

By A. J. Adenigbo, E. E. Okoko & K. T. Gbadamosi

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**Abstract-** The goal for efficient cargo services is dependent upon the level of infrastructure provision at airport terminals. Infrastructure for cargo handling should commensurate with variability in traffic. This study assesses the capacity of infrastructure for cargo operations at terminals of Lagos airport. Data for the study were collected by random sampling of 337 cargo agents and customs officers with the use of questionnaire. The study employed Chi Square and Kruskal Wallis tests to analyse data. It shows that there is adequate infrastructure, which are in good condition for cargo handling. This calls for policy direction to ensure that capacity is not underutilised.

**Keywords:** cargo handling; terminal capacity; terminal infrastructure; capacity utilisation.

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# Assessment of Terminal Capacity for Cargo Handling in Lagos Airport, Nigeria

A. J. Adenigbo <sup>α</sup>, E. E. Okoko <sup>σ</sup> & K. T. Gbadamosi <sup>ρ</sup>

**Abstract-** The goal for efficient cargo services is dependent upon the level of infrastructure provision at airport terminals. Infrastructure for cargo handling should commensurate with variability in traffic. This study assesses the capacity of infrastructure for cargo operations at terminals of Lagos airport. Data for the study were collected by random sampling of 337 cargo agents and customs officers with the use of questionnaire. The study employed Chi Square and Kruskal Wallis tests to analyse data. It shows that there is adequate infrastructure, which are in good condition for cargo handling. This calls for policy direction to ensure that capacity is not underutilised.

**Keywords:** cargo handling; terminal capacity; terminal infrastructure; capacity utilisation.

## I. INTRODUCTION

The capacity of airports to handle cargo traffic is measured by the rate at which cargoes are processed for transshipment. Generally, capacity refers to the ability of an airport to handle a given volume and types of cargo demand without operational penalty. Airport capacity for cargo handling is constrained when the infrastructure and facilities provided at terminals can no longer perform effectively to handle the demanded tonnage of cargo efficiently.

Airport capacity constrain is expressed as the inability of an airport to handle the maximum number of units of demand that can be accommodated during a given period of time and under given conditions (Senguttuvan, 2006). Bilotkach and Polk (2011) stated that airports which are capacity constrained in one or the other way will have difficulty accommodating new airlines or expanded services by the incumbent carriers. The airport capacity and the demand for service by aircraft operators form the major features in the measurement of traffic growth of any airport. These features influence the volume and types of cargoes that an airport can attract.

The focus of airport management is to ensure adequacy of capacity to handle the anticipated demand of traffic in an efficient manner. The overall capacity of any airport to provide cargo handling services with efficiency is determined by the quantity and condition of its infrastructure such that cargoes are processed without delay and at reduced cost. The delay in cargo

traffic at airports results into high cost and increased transshipment time. To this end, this study is set to assess the capacity of Lagos airport in the handling of cargo traffic in terms of the adequacy and condition of warehouse, handling equipment, processing shed, and storage facilities.

The paper is structured under five sections. Following this section is section 2 – literature review, the presentation of detailed methodology for the study is under section 3, section 4 presents the results and discussion while section 5 gives the conclusion and policy implication of the study.

## II. LITERATURE REVIEW

There are several studies on airport capacity across many nations of the world. The focus of many studies in airport capacity has been in relation to aircraft, taxiway and runway. Gelhausen (2011) looked at airport capacity constraints in relation to passengers' airport choice in Germany. Also, Xiao, Fu, Oum&Yan (2017) modelled airport capacity choice in consideration for the real option of expansion. The issue of airport-airline choice was investigated with a focus on airport capacity by Xiao, Fu, Oum & Yan (2017) with a focussing its effect on airport capacity. Magana, Mansouri & Spiegler (2017) considered the need for improving air cargo demand forecasting of handling industry's to provide adequate capacity, while Jacquilat & Odoni (2017) synthesised major interventions available to manage airport demand and capacity. The study of Nommik & Antov (2017) modelled airport terminal capacity to avoid over-design of infrastructure for the provision of cargo handling services in Estonia. Recently, Picard, Tampier and Wan (2019) assessed airport capacity and slot allocation efficiency of flight departures at peak times. Amaruchkul & Lorchirachoonkul (2011) studied air cargo capacity allocation for multiple freight forwarders. The study considered single air-cargo carrier allocating cargo capacity to multiple forwarders before booking starts. Anderson, Wirasinghe & Alexandre (2008) studied the overall level of service (LOS) measures for airport passenger terminals in a single scale according to user perception. Suryani & Chen (2010) studied air passenger demand forecasting and passenger terminal capacity expansion: a system dynamics framework in order to develop a model to forecast air passenger demand and to evaluate some policy scenarios related to runway and passenger terminal capacity. Polak

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(2014) investigated whether the capacity of Schiphol airport and expected demand would balance in the year 2015, and measures that should be taken to accomplish a balance.

The implication from the several studies is that adequate attention had been given to the overall airport capacity in relation to demand, constraints, aircraft flight, and airline choice. This indicates a need for a research that looks at the airport capacity in relation to cargo traffic. Therefore, this study is carried out to assess the adequacy and condition of cargo terminal infrastructure provided by cargo handling companies at Murtala Mohammed International Airport (MMIA), Lagos, Nigeria.

### III. METHODOLOGY

The study adopts survey research method as a means to collect data from the population for the study. The study is designed to select a sample of respondents from the targeted population for questionnaire administration with quantitative approach to analyse data. The goal of this is to expand the frontier of knowledge in the area of air cargo operations at airports using survey and interview methods. The survey successfully administered questionnaire to 337 respondents to form the sample size for the study. The administration of questionnaire was conducted with the use of simple random sampling technique. The major respondents were cargo agents and customs officers. The focus of the questionnaire is the assessment of the capacity of the cargo terminals at the Murtala Mohammed international airport (MMIA), Lagos. The view of the respondents were sought in terms of the adequacy and condition of the terminals' warehouse, handling equipment, processing shed and storage facilities. There are three cargo terminal at MMIA, which are under the operation of NAHCo Aviance, SAHCOL and DHL.

The questions on the airports' capacity assessment were presented in a 3 point Likert scale to indicate level of respondents' perception of the adequacy and condition of cargo terminals' infrastructure. The choice of the 3 point Likert scale is to capture only the positive polar responses ranking as "fairly adequate, adequate and highly adequate" to measure the adequacy of the airports' terminal infrastructure. For the condition of the infrastructure, 3 point Likert scale showing positive responses of "fairly ok, good and excellent" were used. Only positive responses were sought because the negative polar responses of "inadequacy and "poor condition" do not exist with the airports' terminal infrastructure for cargo handling in practical situation.

The study employed simple descriptive method in the form of charts, percentages and frequencies, Chi Square and Kruskal Wallis tests to analyse data regarding the capacity utilisation at cargo terminals in MMIA. The Kruskal-Wallis or one way ANOVA on ranks

is a non-parametric method for testing whether samples originate from the same distribution. It is used for comparing two or more independent samples of equal or different sample sizes. The test statistics of the Kruskal-Wallis analysis the evenness of the distribution of the ranking positions of different groups in the sequence of joint ranks, and if no ties exist it is calculated as follows.

$$H = \frac{12}{N(N+1)} \sum_{i=1}^k \frac{R_i^2}{n_i - 3(N+1)} \quad (1)$$

where N is the total number of observations.

The Kruskal-Wallis model is calculated when ties exist with.

$$H' = \frac{H}{1 - \sum_{i=1}^m \frac{T_i}{N^3 - N}} \quad (2)$$

where  $m$  is the total number of tied sets.

The significance level (at 0.05) is based on the  $\chi^2$  distribution, with  $k - 1$  degrees of freedom.

### IV. RESULTS AND DISCUSSION

#### a) Assessing the Airports' Capacity in Cargo Handling

Infrastructure at cargo terminals are put in place to ensure the capacity of airports to carry out cargo handling services with efficiency. The measurement of airport capacity in cargo operation is determined by the volume of cargo the airport infrastructure can process at a given time. The degree of efficiency of cargo operations is dependent upon time and cost of service delivery. The cost for cargo handling services will increase with increased processing time. This happens when cargo stay longer than required at airport terminal resulting into demurrage, which makes cargo handling services inefficient. The goal of cargo operations at any airport is to ensure timely transit of cargo to its final destination through a network of guaranteed service providers who provide infrastructure capacity for efficient handling.

The level at which the respondents are familiar with the airport's infrastructure in cargo handling in terms of warehouse, handling equipment, processing shed and storage facilities were sought in order to determine the reliability of information provided for the study. Table 1 shows that all the respondents are familiar with cargo operations at the airport. This guarantees that information provided by the respondents can be relied upon for the purpose of the study. The result on the familiarity of the respondents to air cargo operations at MMIA provides the basis for the reliability of the results presented in subsequent tables.



**Table 1:** Respondents Familiarity with Cargo Operations at MMIA

	Frequency	Percent
Yes	337	100
No	-	-
Total	337	100.0

Source: Authors' Field Survey

Table 2 shows that cargo traffic volume at MMIA can be said to be at average level. This is implied from the results showing about 55% of the respondents indicated that the cargo traffic at MMIA is "average" in

relation to the capacity of the airport. It implies that the present level of the airport's cargo traffic volume is not motivating the respondents who were majorly cargo agents and customs officers whose operations and revenue depends on the level of cargo traffic at the airport. The test statistics shows Chi-square ( $X^2$ ) = 128.356 with 2 degrees of freedom, which is significant at  $\alpha = 0.01$  implies that the difference in the view of the respondents for moderate, average and below average cargo volume at MMIA cannot be attributed to chance.

**Table 2:** Perception of Cargo Volume at MMIA with Chi-Square Statistics

	Percent	Observed N	Expected N	Residual	Test Statistics	
Moderate	39.5	133	112.3	20.7	Chi-Square	128.356 <sup>a</sup>
Average	54.9	185	112.3	72.7	Df	2
Below Average	5.6	19	112.3	-93.3	Asymp. Sig.	.000
Total	100	337				

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 112.3

Source: Authors' Field Survey

The implication from Table 2 relates to the result presented in Table 3 indicating that the capacity of the airport in cargo handling is optimally utilised. This accounts for 78% response of the respondents. It therefore implies that the volume of cargo flow at the airport within a given period of time is not beyond the handling capacity of the airport's infrastructure. The Chi-

square ( $X^2$ ) test statistics equals 307.341 with 2 degrees of freedom, which is significant at  $\alpha = 0.01$  implies that the difference in the perception of the respondents about the level of capacity utilisation at MMIA as "underutilised, optimally utilised and over utilised" is not due to chance (See Table 3).

**Table 3:** Perception of MMIA Capacity Utilisation with Chi-Square Statistics

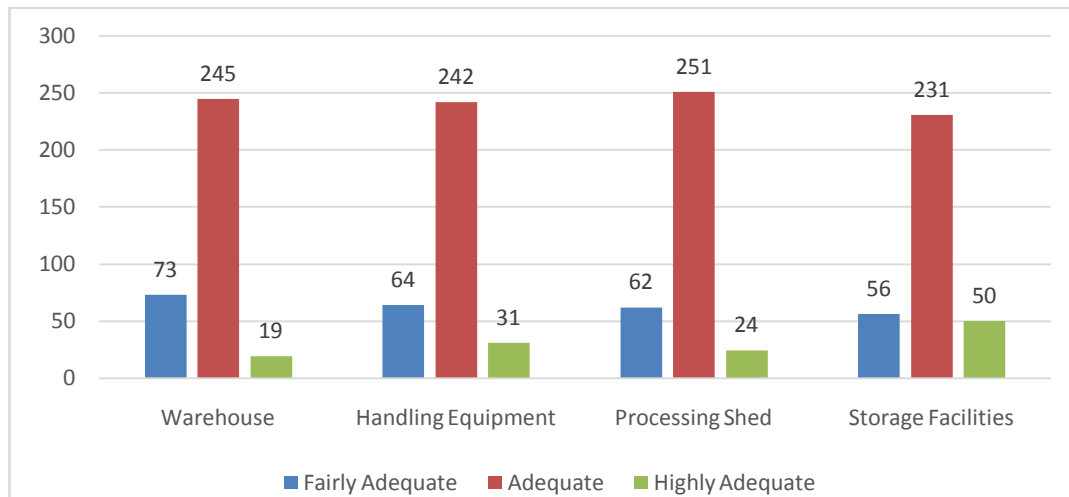
	Percent	Observed N	Expected N	Residual	Test Statistics	
Under Utilised	17.5	59	112.3	-53.3	Chi-Square	307.341 <sup>a</sup>
Optimally Utilised	77.8	262	112.3	149.7	Df	2
Over Utilised	4.7	16	112.3	-96.3	Asymp. Sig.	.000
Total	100	337				

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 112.3

Source: Authors' Field Survey

#### b) Adequacy of infrastructural capacity at terminals of MMIA in cargo handling

The Murtala Mohammed International airport is managed such that cargo handling services of the airport are carried by two major handling companies alongside the services of DHL. The two major handling companies are NAHCo Aviance and SAHCOL. These companies provide, manage and operate infrastructure for cargo operations under customs authority. The primary operation of the companies is to handle aircrafts and cargo for transshipment. But DHL which functions as both express carrier and integrator handles cargo it mainly carries. The capacity utilisation of the airport to handle cargo traffic assessed in terms of the adequacy and condition of warehouse, handling equipment, processing shed and storage facilities of NAHCo Aviance, SAHCOL and DHL is based on the perception of the respondents about the terminals.

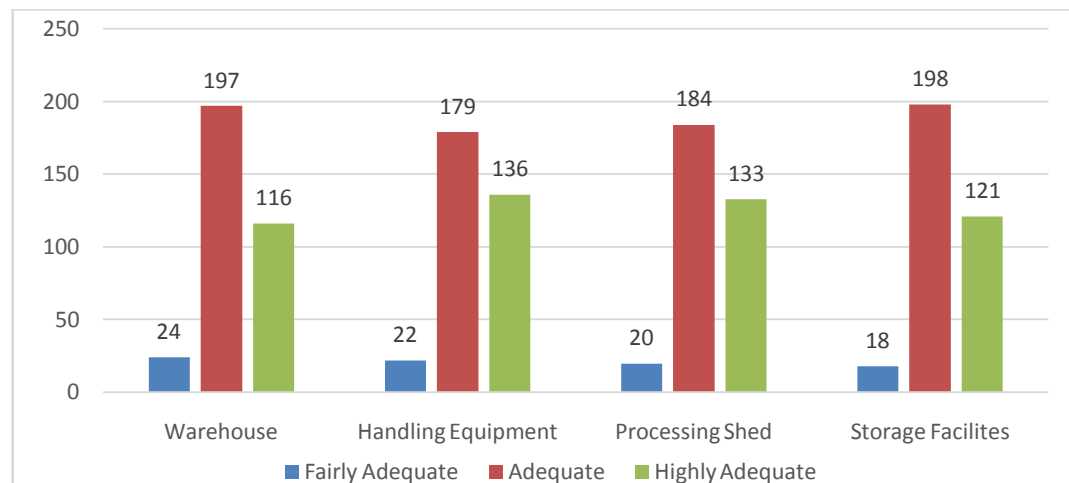


Source: Authors' Field Survey

Figure 1: Adequacy of NAHCo Capacity at MMIA

For the adequacy of infrastructure at NAHCo Aviance terminal, Figure 1 implies that the warehouse, handling equipment, processing shed, and storage facilities are adequate to handle the present cargo traffic. This is accounted for by the responses of the respondents showing that 245, 242, 251, and 231 representing 73%, 72%, 74% and 69% responses

respectively for warehouse, handling equipment, processing shed and storage facilities of NAHCo Aviance. The results in Figure 1 indicates that NAHCo Aviance has the capacity to optimally handle the present flow of cargo at the airport. Going by this, it is indicative that NAHCo Aviance is expected to provide efficient handling of cargo at the airport.



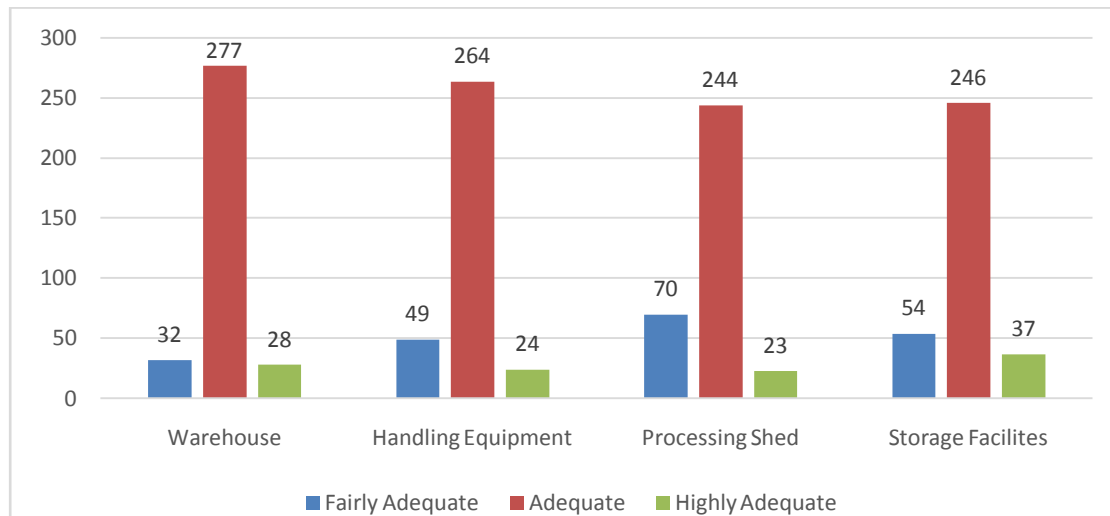
Source: Authors' Field Survey

Figure 2: Adequacy of SAHCOL Capacity

The adequacy of the infrastructure provision by SAHCOL in terms of warehouse, handling equipment, processing shed and storage facilities at the airport is reflected by the results presented in Figure 2. Adequacy of capacity is evident at the terminal. This accounts for the fact that majority of the respondents indicated that warehouse (197 respondents; 58.5%), handling equipment (179 respondents; 53.1%), processing shed (184 respondents; 54.6%), and storage facilities (198 respondents; 58.6%) are adequate to handle the present flow of cargo at the airport. The significance of the respondents who indicated that the infrastructure provision at SAHCOL is "highly adequate" indicates that SAHCOL has the capacity to handle more than it is

presently handling. It also implies that SAHCOL will be able to efficiently handle significant increased cargo traffic at the airport in the future without need for capacity expansion in terms of more infrastructure provision.

The adequacy of the capacity at DHL, which majorly handles express cargo and courier at the airport, was assessed with the results presented in Figure 3. This shows that majority of the respondents are of the view that DHL has adequate facilities to handle the present cargo traffic. This is accounted for as 82%, 78%, 72%, and 73% of the respondents identified DHL warehouse, handling equipment, processing shed, and storage facilities to be adequate respectively.



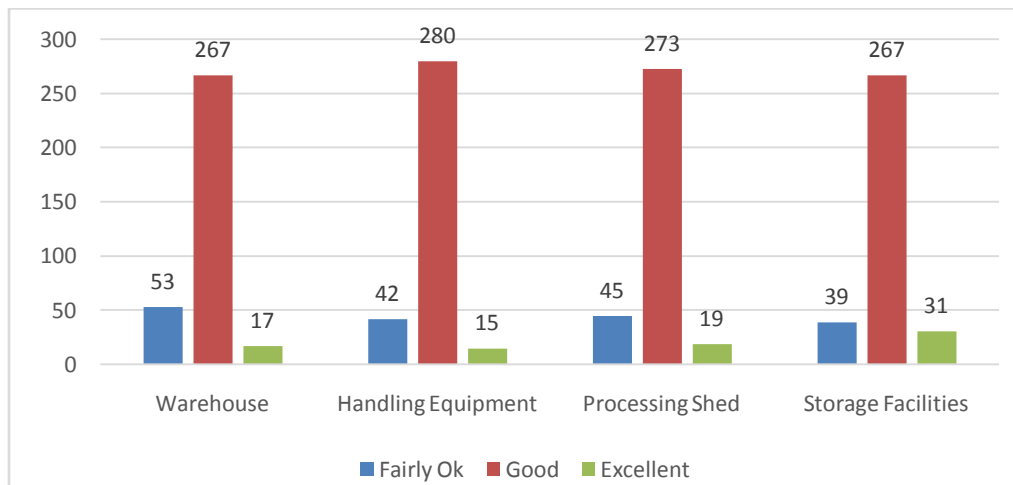
Source: Authors' Field Survey

Figure 3: Adequacy of DHL Capacity

c) Condition of infrastructural capacity at terminals of MMIA in cargo handling

A further assessment of terminal capacity at MMIA in cargo operations looked at the condition of infrastructure provided by handling companies with respect to warehouse, handling equipment, processing shed and storage facilities. The condition of

infrastructure provision at NAHCo Aviance terminal can be judged to be "good". This is as a result of the responses of the respondents accounting for 79%, 83%, 81%, and 79% for warehouse, handling equipment, processing shed and storage facilities respectively as presented in Figure 4.



Source: Authors' Field Survey

Figure 4: Condition of Infrastructure at NAHCo Aviance Terminal

The respondents' view of the condition of NAHCo Aviance infrastructure implies that, in the overall, the facilities and equipment at NAHCo Aviance can efficiently handle the present rate of cargo flow. It should be noticed from Figure 4 that very few of the respondents claimed that the condition of NAHCo Aviance infrastructure is excellent. This predicts an implication for NAHCo Aviance in the sense that efficient cargo handling operations may fail with increased cargo traffic in the nearest future.

The condition of the infrastructure provision at SAHCOL cargo handling terminal is seen to be good by majority of the respondents. This arises from Figure 5 showing that 56%, 50%, 57%, 57% of the respondents indicated that the condition of infrastructure at SAHCOL is good. This indicates that infrastructure at SAHCOL terminal is optimally utilised to handle the present flow of cargo traffic at the airport.

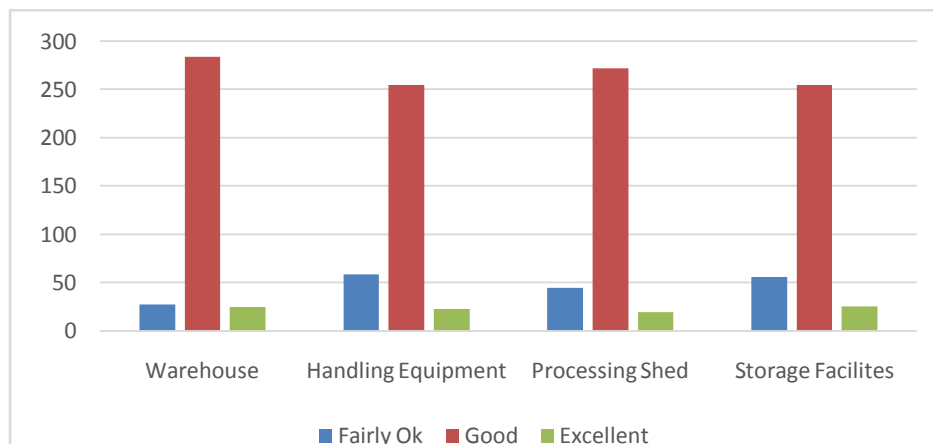


Source: Authors' Field Survey

Figure 5: Condition of Infrastructure at SAHCOL Terminal

However, the uniqueness about the respondents' view of the condition of infrastructure at SAHCOL is the fact that the number of respondents who indicated that the condition of infrastructure at SAHCOL as excellent is significant. This accounts for 38%, 46%, 39%, and 38% for excellent condition of warehouse, handling equipment, processing shed, and storage facilities respectively. The implication of this is that SAHCOL is providing efficient services with an assurance that efficiency of operations will not fail with increased cargo traffic.

The case of the condition of infrastructure at DHL terminal resembles that of NAHCo Aviance. This is from the results presented in Figure 6 showing that majority of the respondents indicated that the condition of warehouse, handling equipment, processing shed, and storage facilities is good. This accounts for 84%, 76%, 81%, and 76% of the respondents view respectively. This implies that DHL is handling cargo volume commensurate with the infrastructure capacity in an efficient manner.



Source: Authors' Field Survey

Figure 6: Condition of Infrastructure at DHL Terminal

#### d) Infrastructural capacity constraint to cargo handling at MMIA

This study assesses the level of capacity constraint with respect to cargo traffic at MMIA from the perspective of the respondents. The respondents were made to rank their perceived level of capacity constraint for cargo demand at the airport. The data collected were subjected to Kruskal-Wallis (H-Test) mean rank analysis. The Table 4 presents the descriptive results of the analysis showing the airport infrastructure (ware house,

handling equipment, storage facilities, and processing shed), the rank levels (fairly constrained, constrained, highly constrained), N, number of respondents, and the mean rank. The high mean rank indicates a more significance.

Table 4: H-Test Descriptive of Infrastructure for Cargo Handling at MMIA

	Levels of Airport Constraint	N	Mean Rank
Warehouse Constraint	Fairly Constrained	142	168.37
	Constrained	145	163.12
	Highly Constrained	50	187.84
	Total	337	
Handling Equipment	Fairly Constrained	142	158.31
	Constrained	145	176.72
	Highly Constrained	50	176.98
	Total	337	
Storage Facilities	Fairly Constrained	142	177.77
	Constrained	145	163.21
	Highly Constrained	50	160.89
	Total	337	
Processing Shed	Fairly Constrained	142	171.82
	Constrained	145	173.39
	Highly Constrained	50	148.26
	Total	337	

Source: Authors' SPSS Computation

It therefore implies that warehouse at MMIA is highly constrained with a mean rank of 187.84. The case of the capacity of handling equipment is unique such that mean ranks of 176.98 and 176.72 is attributed to highly constrained and constrained respectively. The capacity of the airport's storage facilities can be said to be fairly constrained with the highest mean rank of 177.77. The view of the respondents as reflected in the Kruskal-Wallis (H-Test) results for the capacity of processing shed showed the mean ranks of 173.39 for constrained. The results of the Kruskal-Wallis analysis present a situational view about the infrastructure capacity utilisation for cargo handling at MMIA. It reflects that cargo types which require specific handling equipment, and general warehousing are dominant at the airport. And that cargo types which requires storage facilities are fewer in number for handling at the airport. This implies that warehouse and handling equipment at the airport has more cargo volume to handle, which will consequently lead to capacity constraint than storage facilities with less demand.

The H-Test Statistics (Table 5) for the infrastructure capacity constraint at MMIA presented in Table 5 shows whether there is an overall significance difference among the three groups of responses (fairly constrained, constrained, and highly constrained). Notice that the  $p(\text{sig.})$  values for warehouse, handling equipment, storage facilities, and processing shed account for 0.254, 0.185, 0.321, and 0.216 respectively. These values are greater than 0.05 which is the significant level set for the test statistics. It therefore indicates that there is no significance difference among the groups of responses, that is, fairly constrained, constrained, and highly constrained. This implies that infrastructure capacity of the airport is not constrained in relation to ware house, handling equipment, storage facilities and processing shed are not significantly different in the handling of cargo. The conclusion from the H-Test analysis implies that MMIA has the infrastructure capacity to handle its cargo traffic without constraints.

Table 5: H-Test Statistics<sup>a,b</sup> of Infrastructural Capacity Constraint at MMIA

	Warehouse	Handling Equipment	Storage Facilities	Processing Shed
Chi-Square	2.744	3.380	2.270	3.065
Df	2	2	2	2
Asymp. Sig.	.254	.185	.321	.216

Source: Author's SPSS Computation

## V. CONCLUSION AND POLICY IMPLICATION

This study successfully assessed the infrastructural capacity of cargo terminals in Nigeria using Murtala Mohammed International Airport, Lagos by gathering the views of cargo agents and customs

officers regarding the adequacy and condition of warehouse, handling equipment, processing shed, and storage facilities. It is justifiable to conclude from the study that Murtala Mohammed International Airport, Lagos, Nigeria has adequate capacity to handle cargo traffic at its terminals. The adequacy of terminal capacity to handle cargo traffic is a critical means of ensuring



operational efficiency at any airport. The study also showed that cargo infrastructural capacity in terms of the adequacy and condition of warehouse, handling equipment, processing shed and storage facilities at SAHCOL will perform better than NAHCo Aviance in the provision of efficient operations and DHL.

It is evident that efficient cargo operations at airports cannot be achieved without adequate capacity to handle traffic at terminals. In same manner, the condition of infrastructure is paramount to the operational efficiency of cargo handling. To this end, airport management under the control of the Federal Airport Authority of Nigeria (FAAN), need to develop policy to ensure timely upgrade of infrastructure at cargo terminals for adequacy and improved condition. This is necessary since air cargo traffic will continue to increase at airports with regard to increasing population, trade volume and economic activities. Nevertheless, care must be taken to avoid over design of infrastructure such that leads to underutilisation of capacity.

### ACKNOWLEDGEMENT

The authors are grateful to the respondent.

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## Experimental Study of Monotonous and Cyclic Behavior of Silty Sands of Three Hilly Areas in Kinshasa

By Dede Bovulu Gabriel & El Ouni Med. R

**Abstract-** Each slope, of any stiffness, represents under some conditions a risk for the security of humans, of the buildings or the roads, because it can give place to a more or less fast landslide. The phenomenon of the landslide is regarded as a permanent natural danger met in all the countries of the world because the importance of its effects can generate human and material damage being able to amount to million dollars whose governments must pay much attention.

The town of Kinshasa, the capital of the Democratic Republic of Congo, comprising more than 450 heads of very major erosions deserves a detailed attention or better a real assumption of responsibility. Consequently, some hilly areas risk to disappear in the next years because of their vulnerability to the landslide and gullyng.

**Keywords:** *stability of slopes, soil mechanics properties of hills of Kinshasa.*

**GJRE-E Classification:** FOR Code: 290899



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*Strictly as per the compliance and regulations of:*



RESEARCH | DIVERSITY | ETHICS

# Experimental Study of Monotonous and Cyclic Behavior of Silty Sands of Three Hilly Areas in Kinshasa

Dede Bovulu Gabriel <sup>α</sup> & El Ouni Med. R <sup>σ</sup>

**Abstract-** Each slope, of any stiffness, represents under some conditions a risk for the security of humans, of the buildings or the roads, because it can give place to a more or less fast landslide. The phenomenon of the landslide is regarded as a permanent natural danger met in all the countries of the world because the importance of its effects can generate human and material damage being able to amount to million dollars whose governments must pay much attention.

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Because of that, the geotechnical engineer fixes himself like objectives and duties: to ensure to the slopes the stability to prevent possible damage after a careful recognition of the basements to determine the mechanical characteristics and the parameters defining the monotonous and cyclic behavior of grounds of hills of Kinshasa under various stresses.

**Keywords:** *stability of slopes, soil mechanics properties of hills of Kinshasa.*

## I. INTRODUCTION

Each slope, of any stiffness, represents under some conditions a risk for the security of humans, of the buildings or the roads, because it can give place to a more or less fast landslide. The phenomenon of the landslide is regarded as a permanent natural danger met in all the countries of the world because the importance of its effects can generate human and material damage being able to amount to million dollars whose governments must pay much attention.

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Because of that, the geotechnical engineer fixes himself like objectives and duties:

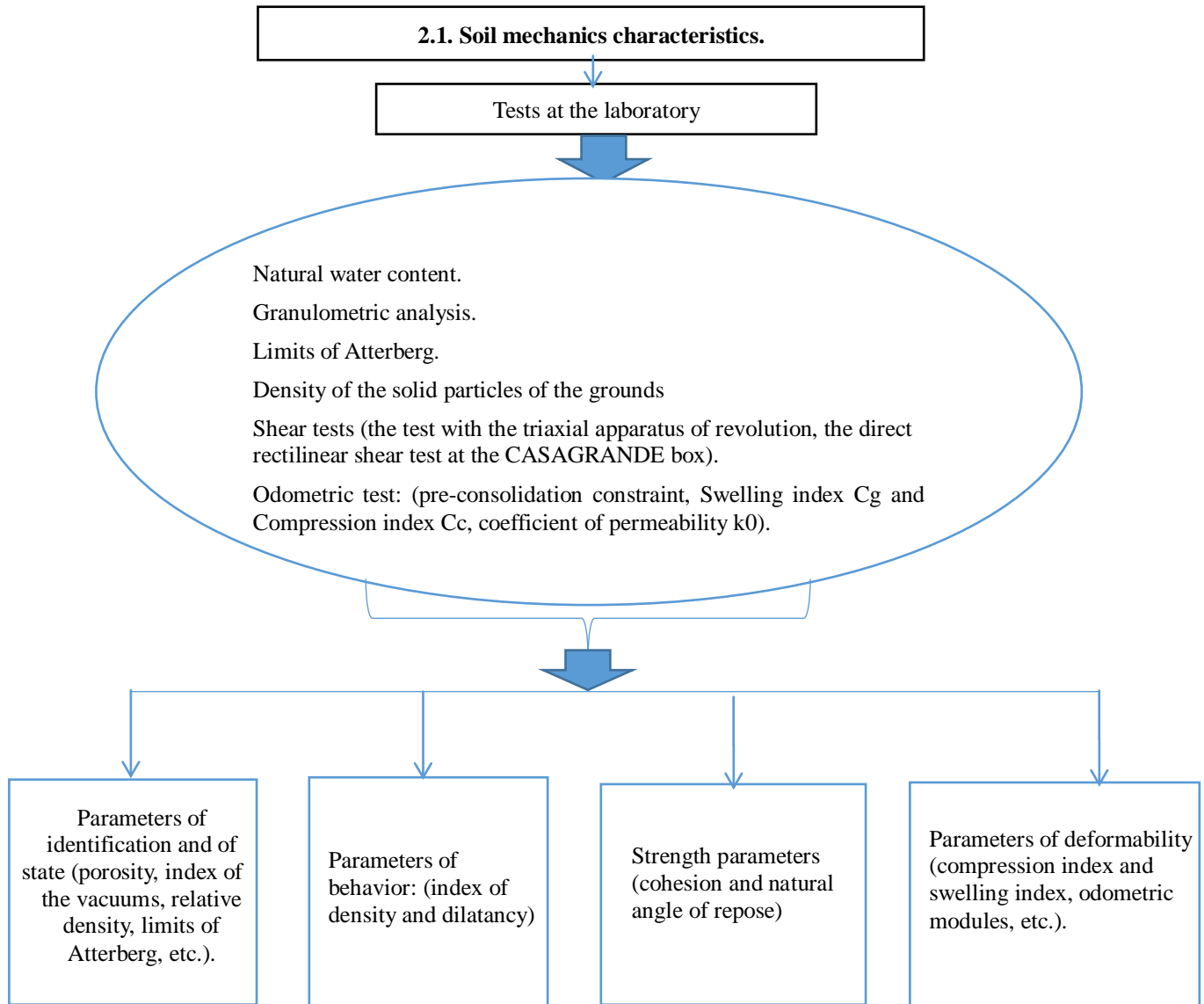
- To ensure itself of the stability of slope to prevent possible damage. There are usually several possibilities. The best is to analyze stability after a careful recognition of the basement, which reflects its temporary degree.
- To take account of this phenomenon, its dangers and the suitable precautions to detect the unstable zones to find the best solutions of protections or processing.

The behavior of the structures requires a detailed study including several stages with knowing: the state of knowledge of the comportment of the grounds under various stresses.

The objective of this study is to understand the behavior of the grounds, their mechanical characteristics, and to determine the parameters defining their mechanical properties.

## II. FLOW CHART OF THE STATE OF KNOWLEDGE OF THE BEHAVIOR OF THE GROUNDS UNDER VARIOUS STRESSES

### a) Soil mechanics characteristics



### b) Experimental behavior

For better understanding the behavior of the sands studied under various stresses, their aptitudes to support loads, their mechanical characteristics and to determine the enumerated parameters above which define their properties, we carried out at the laboratory a series of tests mentioned above.

#### i. Monotonous behavior

In what follows, the parameters of the experimental comportment of sands in drained conditions are presented.

#### a. Parameters of identification and of state of the grounds

(Case of 3 zones of studies: Mont -Ngafula, Kisenso et Binza Delvaux)

#### b. Granulometric analysis

The granulometric analysis of the samples of grounds taken in the 3 zones of studies give grading curve represented below:

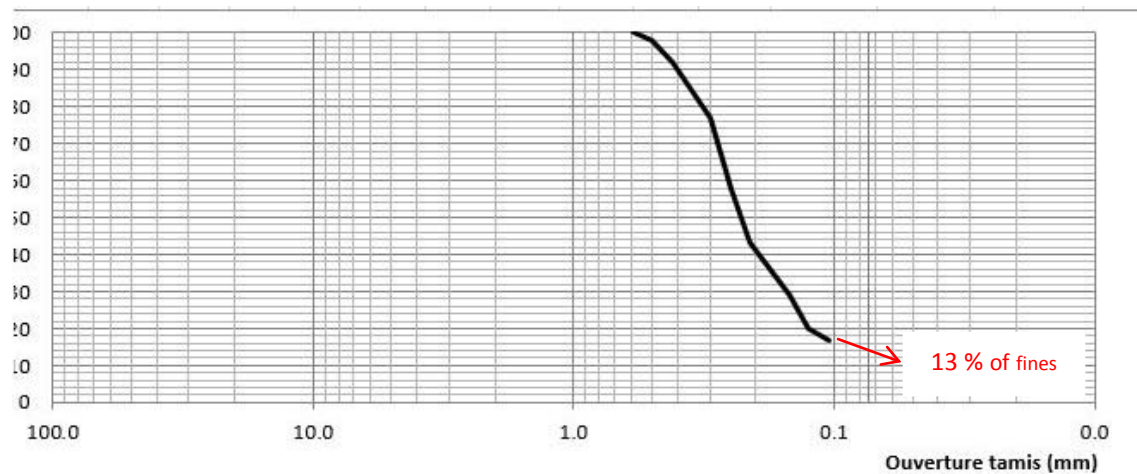


Figure 1: Grading curve of the grounds of Kinshasa

ii. *Parameters of measurement of the behavior of the grounds*

a. *Index of density: ID or relative density:  $D_r$*

It Makes it possible to characterize the behavior of a coarse-grained soil and its aptitude to support loads.

By replacing the data by their values, successive calculations give.

$$I_D = \frac{0,687 - 0,66204}{0,687 - 0,623} = 0,38 < 0,5 \text{ for the silty sand of Kisenso;}$$

$$I_D = \frac{0,35 - 0,346}{0,35 - 0,623} = 0,2 < 0,5 \text{ for the silty sand of Mont-Ngafula;}$$

$$I_D = \frac{0,36 - 0,3559}{0,36 - 0,34} = 0,205 < 0,5 \text{ for the silty sand of BINZA-Delvaux.}$$

b. *Parameters of state:  $\Psi$ , angle of dilatancy*

$$\psi = 30^\circ - \varphi^\circ$$

With  $\varphi$  = the angle of friction

If  $\psi > 0^\circ$ : the behavior of sand is of the loose type primarily contracted and liquefaction will be possible for low values of the parameter of state.

iii. *Shear strength parameters*

Because of the spatial and temporary disparities of the hydromechanics parameters of the grounds, one resorts to the statistics to determine the values of the parameters for the 3 zones of studies.

Table n°1: Shear strength parameters

	C (bars)	$\varphi^\circ$	C (bars)	$\varphi^\circ$
X (average)	0,10	19	0,10	29
$\sigma$ (Standard deviation)	3,54E - 0,2	-	3,54E - 0,2	-
	(1)		(2)	

1) For the zones of studies of Kisenso and Mont-Ngafula

2) For the zones of studies of BINZA-Delvaux (LALU)

iv. *Monotonous drained tests in compression*

a. *Curves of shear strength - drained for the 3 zones of studies*

a. *in the plan  $(T, \epsilon_a)$ ; (Effort of shearing, axial deformation)*



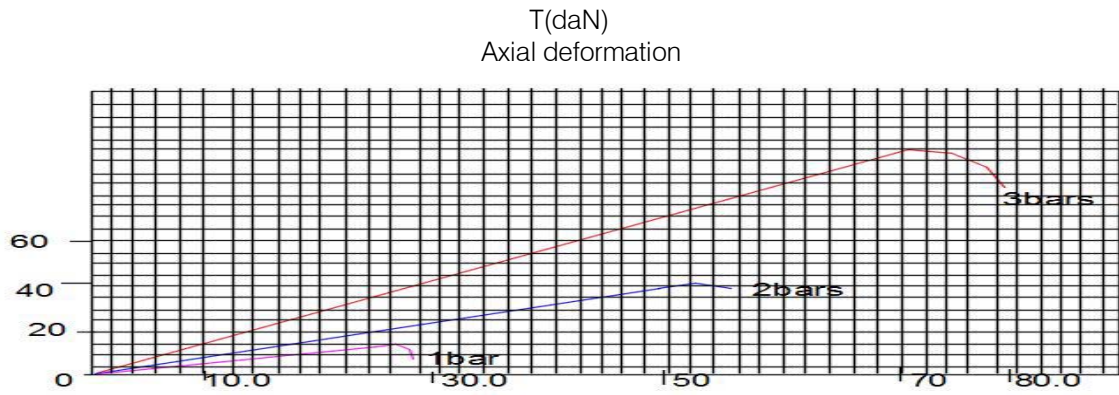


Figure 2: curve constraint -axial deformation of ground of Kinshasa

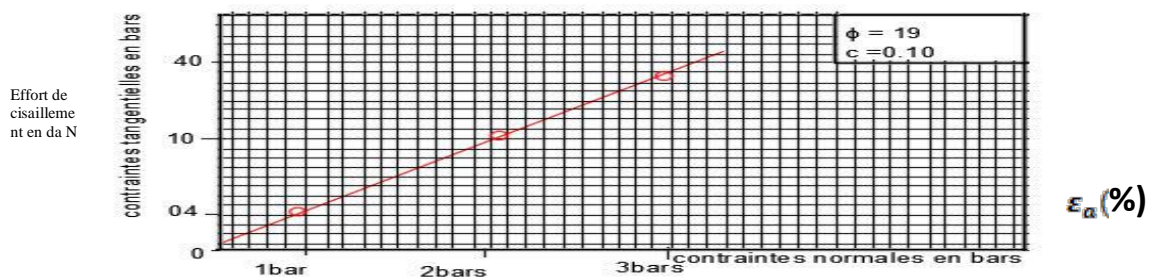


Figure 3: Intrinsic right-hand side of Coulomb (case of Mount-Ngafula and Kisenso)

*The criterion of rupture Mohr - Coulomb:* the intrinsic line of Coulomb makes it possible to separate the zones from elastic and plastic behavior (Figure 3).

Ways of drained constraints whose ultimate states are on the same line of critical state for a given state of density

a) line of collapse in the plan  $(q, p')$

b) line of collapse in the plan  $(q, p')$

Line of stable state: CLS

Line of stable state: FLS

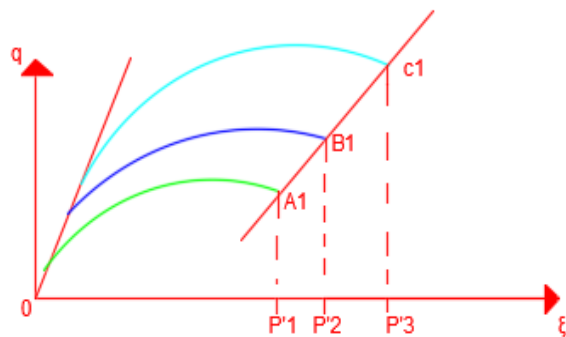
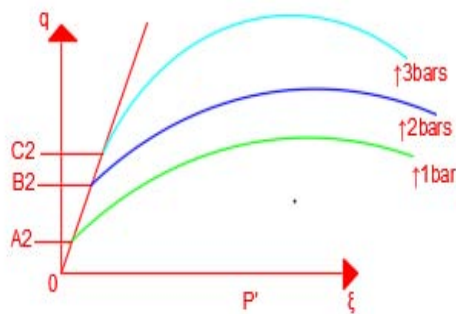


Figure 4: Line of stable state

v. Parameters of deformability (index of compression  $cc$ , initial index of the vacuums  $e_0$ ,  $k_0$  = permeability)

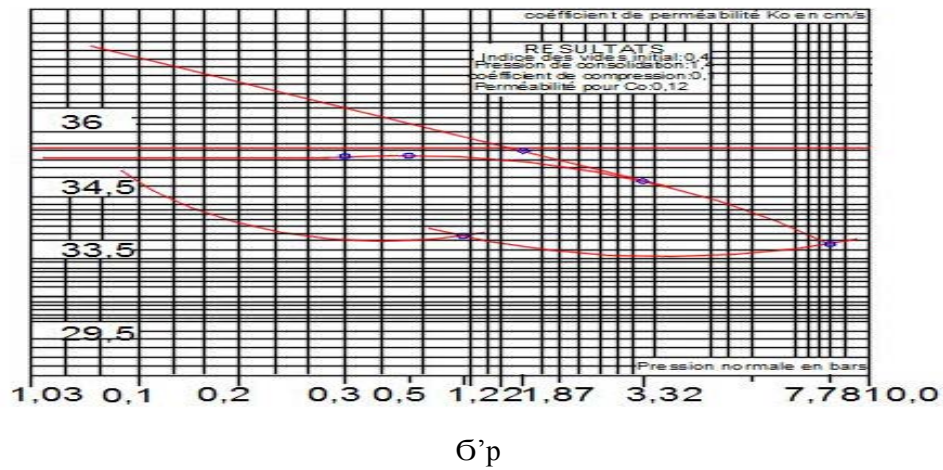


Figure 5: Odometric curve

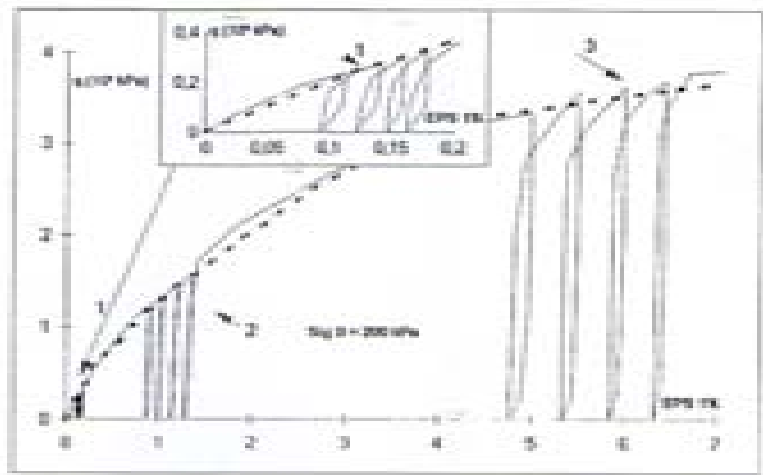


Figure 6: Cyclic tests in imposed deformations (variation of diverter). Loose sand of the hills of Kinshasa

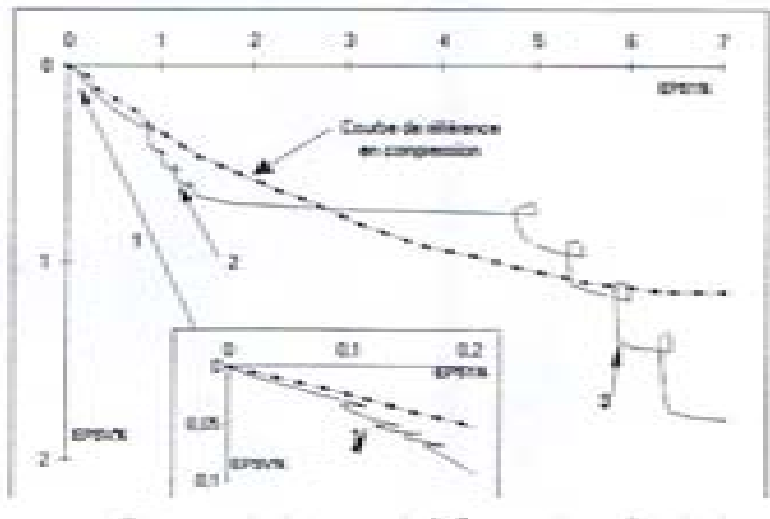


Figure 7: Cyclic Tests in imposed deformations (variation of Volume). Sand Coward of the hills of Kinshasa

### III. RESULTS AND DISCUSSIONS

#### a) For the monotonous behavior

According to the classification of the national laboratory of the bridges and fitted (LNPC<sup>1</sup>), the percentage of the fine particles is  $13\% > 12\%$  one is in the presence of a yellowish silty sand with  $WL = 15,4\% < 35\%$ ;  $w\%$  natural  $= 7,6\% > 0,9\%$ , non-measurable WP; we can thus classify these grounds in the categories of the liquefiable grounds (figure 1)

In term of relative density  $D_r\% = 100$  ID

We obtained the following values respectively:  $38\%$ ;  $20\%$  and  $20,5\% < 40\%$  we are in the presence of loose sand.

About the angle of dilatancy  $\psi$

$\psi = 30^\circ - \varphi$  for  $\varphi = 19^\circ$  and  $29^\circ$ , one finds successively  $\psi = 30^\circ - 19^\circ = 11^\circ > 0^\circ$  and  $\psi = 30^\circ - 29^\circ = 1^\circ > 0^\circ$ .

In both cases; one is in the presence of a yellowish silty sand of the loose type primarily contracted.

Line of stable state (CLS) and line of critical state (FLS)

We observe that the points  $A_2, B_2, C_2$  determine the shear strength in a critical state, the line connecting the points  $A_2, B_2$  et  $C_2$  is called CLS: the critical state line. While the points  $A_1, B_1$  et  $C_1$  indicate the peaks of shear strength then of the shear strength until reaching the zero value; then one speaks about limited liquefaction or a mechanical instability causing a disintegration of the ground or the phenomenon of liquefaction if the shear strength  $\tau = 0$

The line of initiation of liquefaction FLS (The flow liquefaction surfaces)(figure 4).

Classification of the grounds towards the compressibility

One notices for the ground studied the constraint of pre-consolidation:  $\sigma'_p < \sigma'_{z0} \sigma'_p < \sigma'_{z0}$  (normal pressure). It is about loose sand, ground not inflating (Figure 5).

The behavior of the grounds depending on their consolidation statement

$$\frac{c_c}{1+e_0} = 0,097 \frac{c_c}{1+e_0} = 0,097$$

One can give the following appreciations:

$$\frac{c_c}{1+e_0} < 0,015 \frac{c_c}{1+e_0} < 0,015 \quad \text{Incompressible ground}$$

Indeed,  $0,097 < 0,200, 0,097 < 0,20$  : one is in the presence of a compressible ground. It is also a permeable soil because the coefficient of permeability  $k_0$  is worth  $0,12\text{cm/s}$ .

The theory of consolidation allows in plus, to understand the behavior in the time of the grounds under the effect of the permanent loads and also to apprehend the calculation of pressure under the structures.

### IV. CONCLUSION

In comparison with the behavior of the grounds vis-a-vis the various requests and the curve of established shear strength (response), one notes that it is about a yellowish silty sand of the loose type with  $13\%$  of the fine particles, primarily contracted, permeable, compressible, not inflating classified in the category of the liquefiable grounds and presenting the line of initiation of liquefaction "FLS" (The flow liquefaction surfaces).

The behavior of loose sand for a series of triaxial compression tests to various effective constraints of consolidation and the same final resistance of material when the constraint of containment increases. This is due to the increase of the perpendicular force at the point of contact of the grains. In addition, the ratio of the constraints  $\sigma_1/\sigma_3$  fall when  $\sigma_3$  increases, which is due partly to the fact that the corners of the grains break and are flattened at the point of contact and thus the overlap of the particles decreases.

This type of behavior is explained by the following concepts: sand has only internal friction. The skidding resistance between the points of contact of the grains with grains is proportional to the existing normal force, one will then have a total resistance which increases if the constraint of consolidation increases.

The overlap also contributes to total resistance, and it remains almost constant when the constraint of consolidation increases because the grains are flattened at the point of contact, their acute corners break.

- Influence of the index of density  $I_D$  on the behavior of sand C.D

If the relative density increases and becomes  $> 50\%$ ; mechanical characteristics: the angle of friction and cohesion increase ( $\varphi$ ,  $C$ ), then sand is dilating, whereas for studied sands, their relative densities are lower than  $40\%$  thus we are in the presence of a contracting sand in the plan  $(-\xi_v, \xi_a)$  (figure 3).

- Pressure of consolidation influence

One observes on figure 4 that an increase in constraint of consolidation  $\sigma_c$  increases the character contracting of material and in addition in a way almost proportional to  $\sigma_c$  in the plan  $(q, \xi_a)$

<sup>1</sup> LNPC means « Laboratoire National des Ponts et Chaussées ». It is the French national laboratory on bridges and roads.

- Fine particles influence in the sand behavior

If the percentage (13%) of the fine particles increases ( $\nearrow$ )  $> 12\%$ , the shear strength decrease ( $\searrow$ ).

- Angle of dilatancy influence  $\psi$

In all cases  $\Psi > 0^\circ$ : it is noticed that sand is contracting in plan ( $-\xi_v, \xi_a$ )

$\Psi$  is a function of the size of the fine particles and the shape of the grains.

The angle of friction  $\phi$  in the case of loose sand is a constant and the contraction is much more significant than for dense and average sands. this also confirms the results found by other researchers on loose sand.

#### a) *Cyclic behavior*

##### *Cyclic drained tests in imposed constraints*

By analyzing the stress- strain curves in compression, we note:

- The sample of sand undergoes a great irreversible axial deformation during the first cycle and for all the levels of the cyclic loadings (figure 6).

For all the levels of the cyclic constraints applied, the cycles carried out in compression present a significant character at the moment of unloading (third series). At the beginning of the discharge, the curve is almost vertical, it is what gives a very high module  $u$ . At the time when we approach the isotropic state, we noted the appearance of the significant axial deformations and the curve is accentuated. It is noticed however, that the modules of refill and discharge are stronger than the initial tangent module. The irreversible axial deformations accumulated between the first and the last cycle of each series, measured with the thresholds high and low of the cycles are higher in bottom than in top.

- Notwithstanding the various requests applied, in small deformations, nevertheless the sample tends to find a behavior or an evolution similar to the case of the monotonous loading (curve of reference). In the case of the cycles to which the amplitude is close to maximum resistance (cf. 3rd series), we see an increase in the resistance, followed by a reduction during final, consecutive crushing with the cycles. It seems that the material does not forget the history of these stresses (figure 6).
- By analyzing the voluminal curves of deformations (figure 7), we noted a contraction reloads some and the first phase without variation followed by the compaction of material in discharge. The results obtained are in agreement with those obtained by several researchers<sup>2</sup>. For the rather significant deformations, we observed in refill a contraction, discharge and a dilatancy followed by compaction. After the cyclic levels of loadings, the curve of

variations of volume tends to join the curve of variation of monotonous tests (figure7).

##### *Cyclic drained tests in imposed deformations*

The analysis of the results shows that:

- The module of discharge is very high, and does not change the six cycles applied.
- The imposed axial deformation is all the weaker as the average slope in the refill is stronger. In general, the average slope increases by a cycle to another because of the material compaction.
- A dilatancy of material is observed at the beginning of discharge and a contraction with the beginning of refill.
- Notwithstanding the various requests applied the sample tends to find a behavior where an evolution similar to the case of the monotonous loading (curve of reference in compression).

## V. CONCLUSION

The analysis of the results obtained made it possible to draw the following conclusions:

- The application of shear stresses of low amplitudes to a sand sample in drained condition produces a progressive reduction in volume (contraction). Consequently when a saturated sand is subjected to a propagation of waves of shearing during a request of great scale: The period of validity of the cyclic constraint is in general shorter in comparison with that necessary with the drainage of water. An increase in the pore water pressure causes a reduction of the effective pressure what corresponds to a fall of the shear strength which will lead to a rupture of the structure by shearing with catastrophic consequences.

##### *Factors such as:*

- The relative density, the initial state of the constraints, the distribution of the size and the shape of the grains, the history of the constraints in the plan ( $q, \xi_a$ ) and of the way of the constraints followed in the plan ( $q, p'$ ), play a role in the characterization of the behavior of the ground subjected to a cyclic and monotonous loading.
- During the cyclic loading the interstitial pressure increases until reaching the pressure of initial consolidation. The effective constraint is cancelled. It is said that sand is liquified although this phenomenon is temporary. The relative density is one of the essential parameters which govern the phenomena of compressibility under a loading of shearing. It is clear that larger east the tendency to the contraction of the solid skeleton, stronger is the increase in the pore water pressure as well as the potential of liquefaction under the cyclic loading.

<sup>2</sup> El Ouni et al., 1995;1997 and El Ouni, 2000

- It should be noticed that in the case of an isotropic state of stress the pore water pressure reaches the value of the pressure of the consolidation only when the diverter of the constraints is equal to zero in the plan ( $q, p'$ ).
- The presence of the pore water pressure more reduced the hydraulic parameters of the ground in fact: cohesion, the natural angle of repose, effective pressure and shear strength.

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**GJRE-E Classification:** FOR Code: 290899P



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Nadia Moneem Al –Abdalay <sup>α</sup>, Husein Ali Zeini <sup>σ</sup> & Huda Zuhair Kubba <sup>ρ</sup>

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## 1. INTRODUCTION

There are several new type of concrete that are being presented to enhance the strength of the concrete. In such case SIFCON, as a special type of steel fiber reinforced concrete (FRC), has a discrete steel fiber matrix which lends important tensile properties to the composite matrix and because of its high steel fiber content, SIFCON has also unique and superior properties in the areas of both ductility and energy absorption. The major dissimilarity between FRC and SIFCON, in addition to the differences in steel fiber volume fraction and method of production, is the absence of coarse aggregates in SIFCON mortar which, if used, will prevent the infiltration of the mortar through the steel fiber network. Also, SIFCON contains high amount of cement in comparison with conventional concrete and (FRC) [1,2]. The process of preparing SIFCON is different, because of high steel fiber content. SIFCON is produced by first poured steel fibers into a mold until it is completely filled. The steel fiber network of SIFCON is then infiltrated by cement-based slurry. While in (FRC) the steel fibers are mix intimately with wet mix of concrete, prior to mix being sprinkling into forms. The volume of steel fibers (Vf.) is a function of many parameters, such as the shape, diameter, and aspect ratio of steel fibers; their orientation; mold size; placement technique; and the extent of vibration.

External vibration can be applied during the steel fiber placement process. The stronger the vibration, the higher achievable Vf. Some researchers casted SIFCON members layer by layer under vibration to ensure whole infiltration of slurry into the steel fiber pack[3]. Three techniques for incorporating the steel fibers in the matrix was used by[4] to produced SIFCON. In the first case, the steel fibers were repacked in the molds and the slurry was allowed to infiltrate the steel fiber pack, assisted by a table vibrator (single-layer technique). The second technique involved initial placing and packing of the steel fibers in the mold only up to one-third depth, followed by infiltration of the slurry up to this level. The contents in the mold were then vibrated. The process was repeated until the entire mold was filled and compacted (three-layer technique). The third technique consisted of filling the mold up to one-third depth by the slurry, implanting the steel fibers into it immediately thereafter, vibrating the contents and repeating the process until the mold was full (immersion technique). The researchers found that the three techniques used for incorporating steel fibers in the mortar slurry proved effective during the casting of the SIFCON specimens. However, the three-layers and immersion techniques were found to be easier and simpler in real practice than the single-layer technique. Also he studied SIFCON specimen's behavior under impact loads. The impact test was carried out using the test rig. The weight of drop was 50 kg, and The drop height was varied from (250 – 1000) mm. The test results show that, the extent of damage in SIFCON due to impact load was found to be far less when compared to plain mortar and normal fiber reinforce mortar. The SIFCON process needs special attention relating mostly to the need of avoiding non-uniform fiber distributions and of avoiding unfavorable fiber orientation. The fiber density at the interior can be much higher, compared to the edges. Also, a number of fibers may align vertically along the outer surface. One method to escape the edge effect and fiber orientation problems is to cast a slab and get the test specimens by coring. Also, care should be paid to the orientation of fibers. If fibers are aligned along the diameter of the cylinder, a much higher compressive strength can be expected related to a cylinder in which fibers are aligned along the axis of the cylinder [5]. The behaviour of SIFCON slabs under impact loading was studied by[6]. The test was conducted by using impact testing machine with steel ball drop weight. The results reveals that SIFCON slabs with 12% fiber content shows excellent performance in strength and toughness characteristics compared to fiber reinforced concrete,

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reinforced cement concrete and plain cement concrete slab specimens. [7] studied the experimental investigations on partial substitution of cement with fly ash in concrete mix design. Cement was partially replaced with fly ash in the range of 0%, 10%, 20%, 30% and 40% for making concrete mix design normal and high strength concrete mix. The compressive strength and splitting tensile strengths were reduced with increased percentage of fly ash content, but cost of concrete decreased due to reduction of quantity of cement. [8] studied the mechanical properties and flexural properties of SIFCON specimens and compared with conventional concrete of grade M40. The cement based slurry is a composition of cement, fly ash, silica fume, Ground Granulated Blast Furnace Slag. From the results obtained it is found that SIFCON specimens are much better than conventional concrete. [9] investigated the effect of several factors on the impact resistance of SIFCON. These factors are; fiber volume fraction (6%, 8.5%, and 11%), SIFCON mortar type (using silica fume and/or fly ash as a replacement of cement), and different fiber type was using (hooked end fiber, micro steel fiber and hybrid fiber which are varies in their aspect ratio (l/d) and geometry). A conventional fiber reinforced mortar with 2% hooked fiber content is also produced as a control (reference) mix to be compared with SIFCON mixes. The impact resistance of SIFCON specimens was carried out using disc specimen (152 mm diameter by 63 mm thick). the results show that in

general, SIFCON mixes exhibited higher mechanical properties as compared with reference mix.

## II. EXPERIMENTAL PROGRAM

The experimental work was carried out by casting cubes of size  $100 \times 100 \times 100$  mm to find the compressive strength, prism of size  $100 \times 100 \times 400$  mm to investigate the flexural strength, cylinder of 100 mm diameter and 200 mm height were casted to obtain the splitting tensile strength and plate of size  $500 \times 500 \times 40$  mm to find impact resistance. The edges of the mold were sealed with plaster of Paris to prevent the leakage of slurry. The micro steel fiber is dispersed in a random manner to the volume fraction. Compaction by table vibrator was used to ensure complete penetration of the slurry into the micro steel fiber pack. After twenty-four hours of casting, the cubes were demolded and cured in water for the test day.

## III. MATERIALS USED

### a) Cement

Ordinary Portland cement which is commercially known as (Krasta), produced in Sulaymaniyah, was utilized in this study. It's chemical composition and physical properties are presented in Table (1), the results show that the cement utilized conforms to the Iraq specification No. 5/ 1984 [10].

Table 1: Chemical composition and main compounds of the cement used

Oxide	%	I.Q.S. 5: 1984 <sup>[10]</sup> Limits
CaO	66.11	—
SiO <sub>2</sub>	21.93	—
Al <sub>2</sub> O <sub>3</sub>	4.98	—
Fe <sub>2</sub> O <sub>3</sub>	3.10	—
MgO	2.0	< 5.0
K <sub>2</sub> O	0.75	—
Na <sub>2</sub> O	0.35	—
SO <sub>3</sub>	2.25	< 2.8
Loss on Ignition (L.O.I)	2.39	< 4.0
Lime Saturation Factor	0.93	0.66 - 1.02
(L.S.F) Insoluble residue (I.R)	1.29	< 1.5 %
Free lime (F.L)	0.67	—
Compound Composition	%	I.Q.S. 5: 1984 <sup>[10]</sup> Limits
C <sub>3</sub> S	58.16	—
C <sub>2</sub> S	19	—
C <sub>3</sub> A	7.95	—
C <sub>4</sub> AF	9.43	—
Physical Properties	Test Results	I.Q.S.5:1984 <sup>[10]</sup> Limits
Fineness, Blaine, cm <sup>2</sup> /gm	3300	> 2300
Setting Time:		
Initial hrs.; min	1;08	≥ 45 min
Final hrs.; min	4;00	≤ 10hrs
Compressive Strength MPa		
3-days	20,0	≥ 15
7-days	25,0	≥ 23

b) *Fine aggregate (sand)*

Locally available river sand passing through 4.75 mm sieve was used. The specific gravity was found as 2.62. Table (2) shows the sieve analysis and the

grading curve of the used sand. It conforms to the limits of Iraq specification No. 45/1984[11], Zone (2). The chemical and physical properties of natural sand are illustrated in Table (3).

*Table 2:* The sieve analysis of the used sand

Sieve size (mm)	Passing by weight%	I.Q.S.45/1984 [11] Zone(2)
9.5	100	100
4.75	98.5	90-100
2.36	92.4	75-100
1.18	82.0	55-90
0.6	47.5	35-59
0.3	14.4	8-30
0.15	3.2	0-10
pan	2.23	<5

*Table 3:* Properties of the used sand

Properties	Test results	I.Q.S.No.45 [ 11 ]/1984
Specific gravity	2.6	-
Bulk density(kg/m <sup>3</sup> )	1670	-
Sulfate content%	0.34	≤ 0.5%
Absorption	2	-

c) *Supplementary Cementitious Material*

i. *Silica Fume*

Silica fume conforming to ASTM C 1240[12] was utilized in this study as a partial replacement (10%)

by weight of cement. The technical specifications of silica fume are presented in Table (4).

*Table 4:* The technical specifications of silica fume

Structure of material	Silica fume	Limits of ASTM C 1240-05 [12 ]
Color	Dark gray	
Density	0.55-0.7 kg/m <sup>3</sup>	
Chlorine amount	< 0.1 %	
Specific surface area (cm <sup>2</sup> /gm)	> 150000 cm <sup>2</sup> /g	≥ 150000 cm <sup>2</sup> /g
SiO <sub>2</sub>	> 85 %	≥ 85 %
CaO	< 1 %	
Activity index	156 %	≥ 105 %
Specific gravity	2.2	

ii. *Fly Ash*

Class F fly ash (FA) produced from Thermal Power plant in Turkey is used as an additive according

to ASTM C 618 [13], cement is replaced by (20%) of fly ash by weight of cementitious material. The physical and chemical properties are presented in Table (5).

*Table 5:* Physical and chemical properties of class (F) fly ash

Particular	Fly ash (Class F)	ASTM C 618 Class F fly ash[13]
<b>Chemical composition</b>		
Silica (SiO <sub>2</sub> )%	65.65	(SiO <sub>2</sub> + Al <sub>2</sub> O <sub>3</sub> + Fe <sub>2</sub> O <sub>3</sub> ) ≥ 70
Alumina (Al <sub>2</sub> O <sub>3</sub> )%	17.69	
Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> )%	5.98	
Lime (CaO)%	0.98	
Magnesia (MgO)%	0.72	
Sulphur Trioxide (SO <sub>3</sub> )%	0.19	Max. 5.0
Loss on Ignition	3.1	Max. 6.0
Na <sub>2</sub> O	1.35	
K <sub>2</sub> O	2.98	
<b>Physical properties</b>		
Specific gravity	2.12	
Fineness (cm <sup>2</sup> /gm)	3600	Min. 2250cm <sup>2</sup> /gm

d) *High range water reducing admixture (HRWR)*

(Glenium 54), from BASF company, was used as a HRWR. It is free from chloride and compiles with ASTM C494-05 Type F [14]. Glenium 54 is based on a carboxylic ether polymer with long later chain which

greatly improves cement dispersion at the start of mixing process. HRWR had a dosage of 2liters per 100 kg of cementitious materials, Table (6) shows the main properties of the (HRWR).

Table 6: Typical properties of SP (Glenium54) \*

Form	Viscous Liquid
Commercial name	Glenium 54
Chemical composition	Sulphonated melamine and naphthaline formaldehyde condensates
Appearance	Whitish to straw colored liquid
Relative density	1.07 gm/cm <sup>3</sup> at 20 °C
Chloride content	Nil.
pH	5-8
Storage	Should be stored in original containers and at above 5 °C
Transport	Not classified as dangerous
Labeling	Not hazard label required
Alkali content (as NaO <sub>2</sub> ) equivalent)	0.26%

\*According to manufacturer

e) *Water*

Fresh water available from local sources was used for mixing and curing of specimens.

f) *Micro Steel Fiber*

Micro steel fibers are used in SIFCONs to enhance some properties and improve the ductility, the properties are summarized in Table (7). Micro steel fiber (6%) volume fraction  $V_f$  was randomly distribution by hand.

Table 7: Specification of Micro Steel Fiber\*

Property	Specification
Type	WSF 0213
Surface	Brass coated
Tensile Strength	2850MPa
Length	15mm
Diameter	0.2mm
Aspect ratio	65

\*According to manufactu 4- Mix:

The proportion of the constituents for the prepared slurry mix is 1:1 (by weight) of ordinary Portland cement and cementitious materials (Silica fume and Fly ash) to sand, while the water/binder ratio was kept constant as 0.3 (by weight). The super plasticizer (SP) had a dosage of 2liters per 100 kg of cement materials, (6%) volume fraction of micro steel fiber was choosing to reinforced SIFCON mix. A conventional micro steel fiber reinforced mortar, with (2%) fiber volume fraction, was also prepared as a comparison (reference) mix with SIFCON mix. The mixing procedure used to produce SIFCON was as described:

- Before mixing operation, the mixer was cleaned off from any remaining fresh or hardened materials from the older mix.
- Firstly, add cement, fly ash and silica fume while mixer operating at low speed for 30 sec. until a uniform distribution is reached,
- Secondly, add sand and mixing for 1 min. at medium speed,0
- Thirdly, first part (2/3) of water was added and mixed thoroughly for 30 sec. at low speed,
- stop 2 min to clean blades,
- Now, adding SP and remainder water and mixing for 2 min. at normal velocity,
- Stop the mixer and wait for 1 min., and then finalize the process by mixing at normal velocity for 3 min. After many trails of casting technique in the laboratory, two-layer technique was used for incorporating the steel fiber into the SIFCON.

According to reference [9] two-layer technique was utilized for combining the micro steel fiber into the SIFCON matrix. The two - layer technique involved primary placing and packing the micro steel fiber which were oriented in random method, in the mold only up to half depth, followed by filling the mold by the slurry up to half depth. The slurry has to be flow able enough to ensure infiltration through the micro steel fiber. This procedure was repeated (for the second layer) where the entire mold was filled with the required volume fraction of fiber. No vibration was applied.

#### IV. TESTS FOR FRESH SIFCON MORTARS

a) *Determination of Slump-Flow*

The test apparatus for measuring the flow and viscosity of mortar the dimension of slump – flow is show in Fig. (1).The subsequent diameter of the mortar



is measured in two perpendicular directions and the average of the diameters is stated as the spread of the mortar. In this test, the truncated cone mold is sited exactly on the (100mm) diameter graduated circle marked on the glass plate, filled with mortar and lifted

upwards. Fresh properties of mortars were calculated by the mean value two perpendicular flow diameters in the spread test. The procedure for test was followed as described in [15].

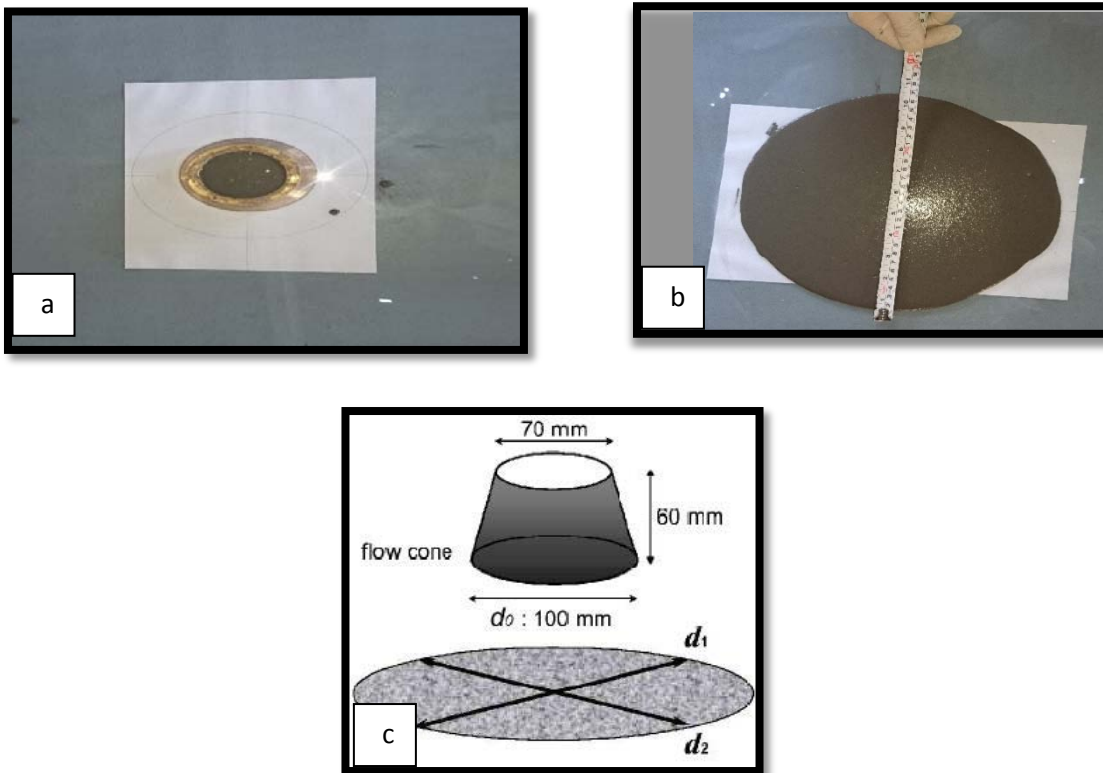


Fig. 1: Mini slump flow test (a, b), (c) the apparatus used [15]

#### b) Determination Flow Time

Flow time determined in the v-funnel test, the dimension of v- funnel is show in Fig. (2).

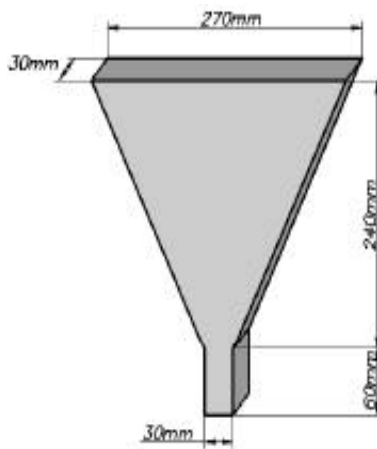


Fig. 2: V-Funnel test apparatus [15]

## V. TESTING OF HARDENED SIFCON

### a) Compressive strength test

The compressive strength test was carried out on 100 mm cube, by using a 2000 kN capacity hydraulic testing machine type ELE digital testing. The loading rate was applied at 0.3 N/mm<sup>2</sup> per second according to BS.1881: part 116[16]. The Specimens were tested at the ages of 7, 28, and 90 days of water curing. The average of three specimens was recorded for each variable in this test.

### b) Splitting tensile strength test

Splitting tensile strength test was carried out according to ASTM C496-04[17]. Cylindrical specimens of 100×200 mm were employed and the average result of two specimens at ages of 7,28, and 90 days was taken for each mix. The splitting tensile strength can be calculated from equation (1). Splitting tensile strength test was made by ELE Digital Elect testing machine. The loading rate used in the test is 0.3 N/mm<sup>2</sup> per second.



$$F_{st} = 2P/\pi LD \quad (1)$$

Where:

$F_{st}$ : Splitting tensile strength (MPa). P: applied load (N).  
D: diameter of the specimens (100mm). L: length of the specimens (200mm).

c) *Flexural strength (modulus of rupture)*

This test was performed in accordance with ASTM C1609-12[18], using prismatic specimens of 100×100×400mm simply supported beam. The specimens were tested under two point loads with a constant rate of loading about 0.015MPa/sec. The specimens were tested at ages of 7, 28 and 90 days and the average of two specimens was recorded. The flexural strength (modulus of rupture) was calculated using the following formula:

$$f_r = \frac{PL}{bd^2} \quad (2)$$

where

P: maximum applied load, (N). L: Span length of specimen, (mm).

b: the width of the specimens, (mm). d: the depth of the specimen, (mm)

d) *Impact resistance test*

Steel molds with (500×500×40mm) are fabricated for casting the plates specimens. The molds are made of (4 mm) thickness steel and their side pieces are connected by bolts which can simply be removed and fastened. The same procedure casting for other SIFCON test was utilized for impact resistance. Fig (3) show the impact resistance mold during casting.

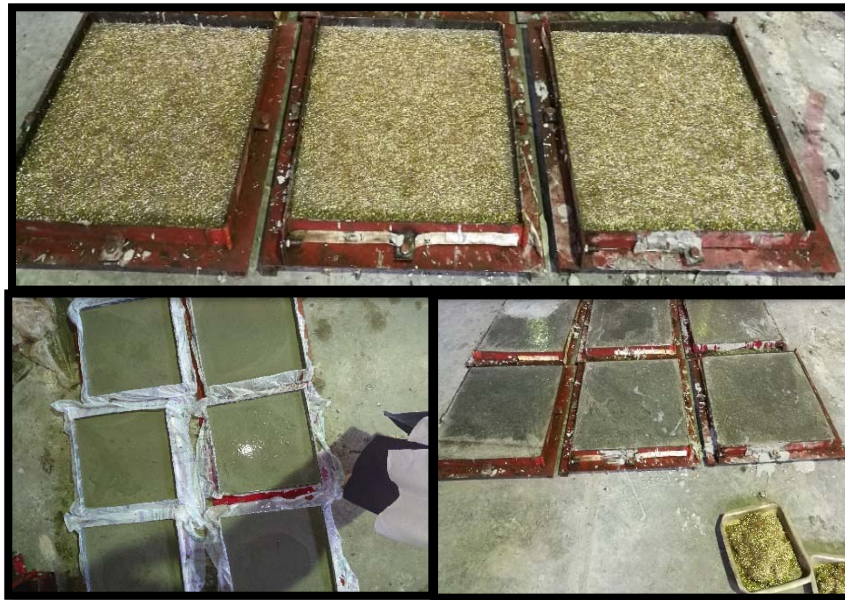


Fig. 3: Impact resistance mold during casting. a) micro steel fiber pack, (b) during slurry cast, (c) after hardened specimens

A steel frame was manufactured, for this test and the instrument Schematic diagram and picture was presented in Fig. (4). The test procedure adopted is as (5kg) steel mass was released from a height of (1m) repeatedly, which would come in contact with the top surface of the center of plate specimens. The number of impact blows until the appearance of first visible crack was recorded. The loading was then continued and the number of blows until failure was recorded. In average, three plate specimens are adopted in this instrument for 90 days' age. The energy absorption value was obtained by:

$$E = N \times (w \times h) \quad (3)$$

Where; E is the energy in joules, w is weight in Newton, h is the drop height in meter and N is the blows in numbers.

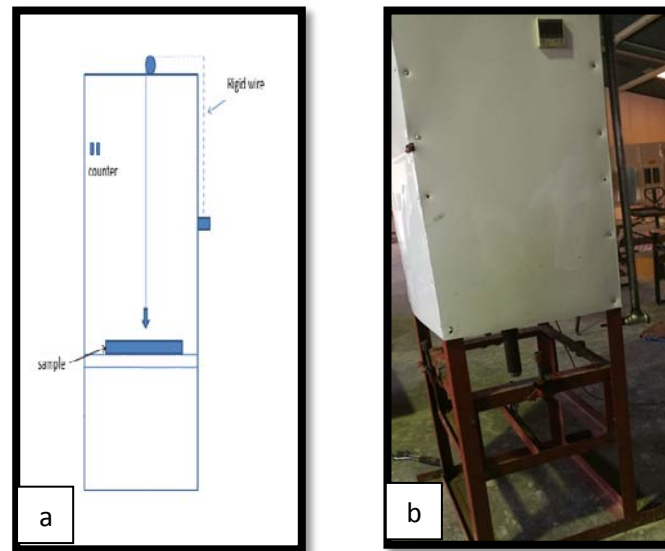


Fig. 4: Impact test apparatus, (a) Schematic diagram, (b) impact test instrument.

## VI. RESULTS AND DISCUSSION

### a) Fresh SIFCON Properties

The test results related to the slump flow diameter, V-funnel flow time are presented in Table (8). From result show the mixture had slump flow diameter, V-funnel flow time conforming [15]. Where  $D_m$  is the

mean value of the two perpendicular diameters, measured in (mm);  $D_0$  is the initial diameter of the base of the cone, measured in (mm), and finally, the (t) represents the time of flow in the v-funnel, which is measured in second.

Table (8): Fresh properties of SIFCON mortars\*

Slump Flow Diameter (cm)	V-funnel time (s)	$G_m = \left(\frac{D_m}{D_0}\right)^2 - 1$	$R_m = \frac{10}{t}$
25.8	8	5.65	1.25

\* The EFNARC [15] requirements are: a value between (240-260) mm spread diameters is required for mini slump flow test and a flow time between (7-11) seconds for V-funnel tes

### b) Hardened SIFCON Properties

#### i. Compressive Strength

The compressive strength test results for SIFCON cubes  $100 \times 100 \times 100$ mm cured in water until days of test at age of 7,28 and 90 days, from the results showed in Table (9) and Fig. (4), the strength increased with ages. This development in compressive strength can be attributed to the fact continuous the hydration process (C-S-H), also present of silica fume tends mainly to consume the calcium hydroxide crystals released from the hydration process leading to the creation of further calcium -silicate- hydrate (secondary C-S-H).

The increase in fiber fraction from 2% (reference) to 6% (SIFCON) mix leads to enhance the compressive strength of SIFCON mix to (73.2,75.4 and 65.3%) at age of 28,60 and 90 days respectively. This enhance in compressive strength is due to the developed gained bond between micro steel fiber/matrix interfaces by increasing micro steel fiber  $V_f$ , in addition to the effect of micro steel fiber in bridging the microcracks growth, and therefore lead to higher strength of the composite, these results are in agreement with other researchers [3, 4, 5,9].

Table (9): Results of Hardened Properties of SIFCON Mix

Group NO.	Mix Symbol	Compressive Strength (MPa)			Splitting Strength (MPa)			Flexural Strength (MPa)		
		7 days	28 days	90 days	7 days	28 days	90 days	7 days	28 days	90 days
Reference	R	55	62.3	72.1	5.5	7.1	9.9	7.6	9.9	11.0
SIFCON	S	95.3	109.3	119.2	16.1	19.8	21.9	18.0	24.3	28.0

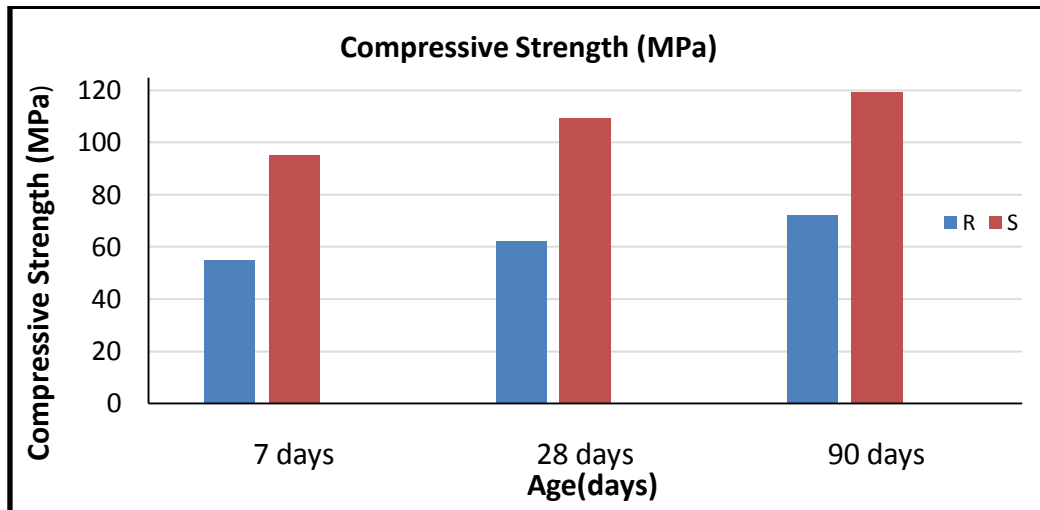


Figure (4): Compressive Strength of SIFCON Mix.

### ii. Splitting Strength

The tensile strength values of SIFCON mix were carried out at the different ages of 7, 28, and 90 days, are presented in Table (9) and plotted in Fig. (5). It shows that, SIFCON specimens have superior tensile properties, important enhance in tensile strength by about (1.92, 1.81 and 1.21%) at age of 7, 28 and 90 days respectively. This enhanced can be attributed to the

microcracks can be controlled by arresting and bridging mechanism of fiber. Also the using micro steel fiber leads to an improved bond between fiber and matrix, hence improvement in mechanical properties of SIFCON. This result is in agreement with other researchers [3, 4, 5, 9].

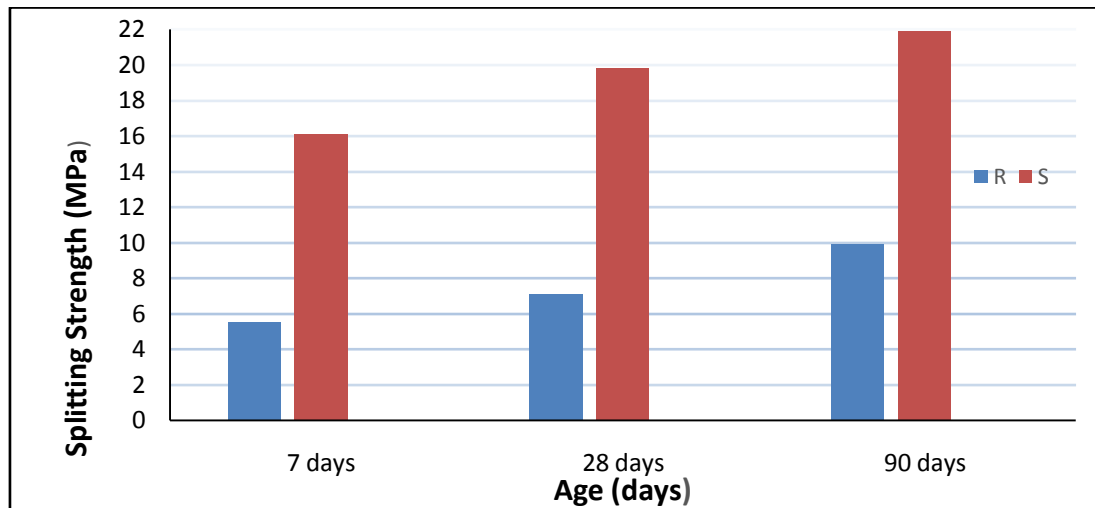


Figure (5): Splitting Tensile Strength with Age for SIFCON Mix

### iii. Flexural strength

The flexural strength values of SIFCON specimens at different ages for SIFCON mix and also the flexural strength of reference mix, are presented in Table (9) and presented in Fig. (6). It is obvious that, important enhance in flexural strength by about (1.36, 1.45 and 1.54%) at age of 7, 28 and 90 days respectively, when comparing the results of SIFCON specimens with that of reference specimens. This result can be attributed to the stronger and greater interface zone between binder and micro steel fibers which enhances

the bond strength and decreases the growth of microcracks which leads to flexural failure. This result is in agreement with other researchers [3,4, 5,9].

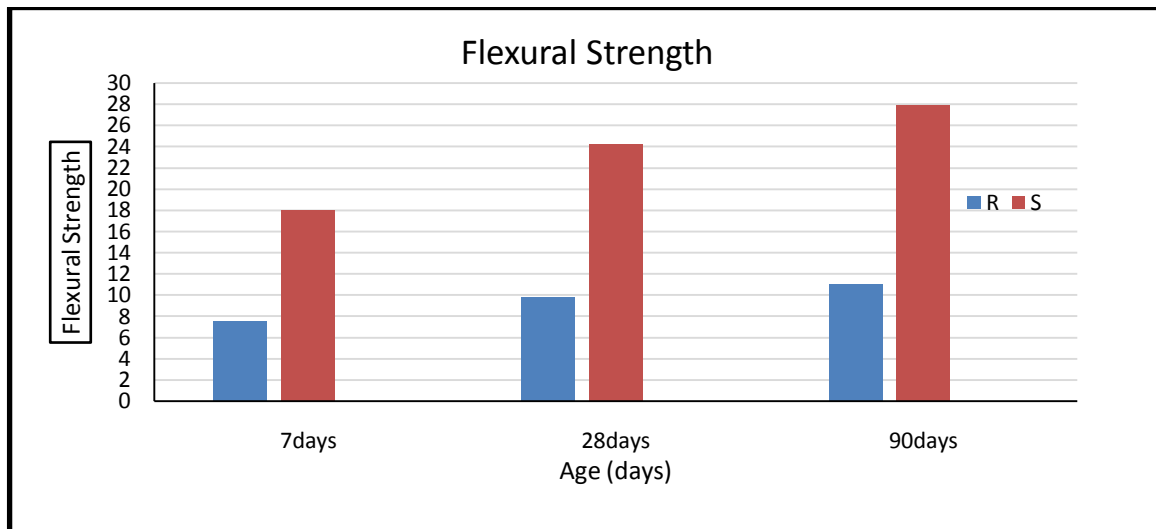


Figure (6): Flexural Strength with Age for SIFCON Mix

#### iv. Impact Resistance

The results of number blows required to first and failure crack at age of 90 days are present in Table (10) and Fig. (7). The test results show that a significant development in impact resistance for SIFCON mix at first crack and failure compared with the conventional mortar (reference) mix by about 8.77%, 8.97% for initial crack and complete failure respectively. SIFCON mix exhibited the highest impact resistance, and the energy required for complete failure was (65089.35 joules)

which is increased by 9.97 times, compared to the reference mix at 90 days as show in Table (10) and Fig. (8). Also this result was much higher than that of high performance fiber reinforced concrete which is ranged between (3000- 50000 joules)[19, 20]. This result is in agreement with other researchers [4, 9], and can be attributed to the ability of micro steel fibers in absorbing high amount of impact energy because of its high tensile strength and high ductility.

Table (10): Impact resistance for SIFCON specimens at 90 days' age.

Group No.	Mix symbol	Number of blows to cause		Impact energy (joules)		Residual impact strength ratio (Irs)
		Initial Crack	Complete Failure	Initial	Failure	
Reference	R	44	133	2158.2	6523.65	3.02
SIFCON	S	430	1327	21091.5	65089.35	3.08

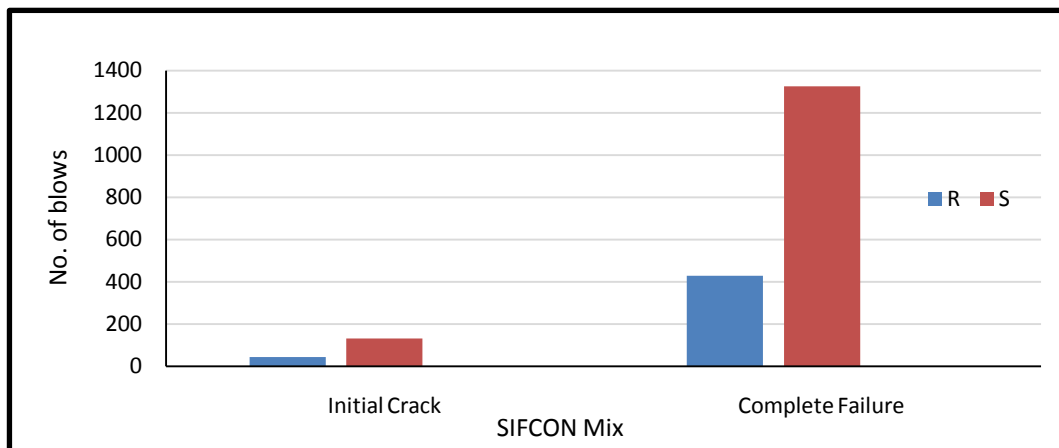


Fig. (7): Number of blows required to cause first crack and complete failure of SIFCON mix

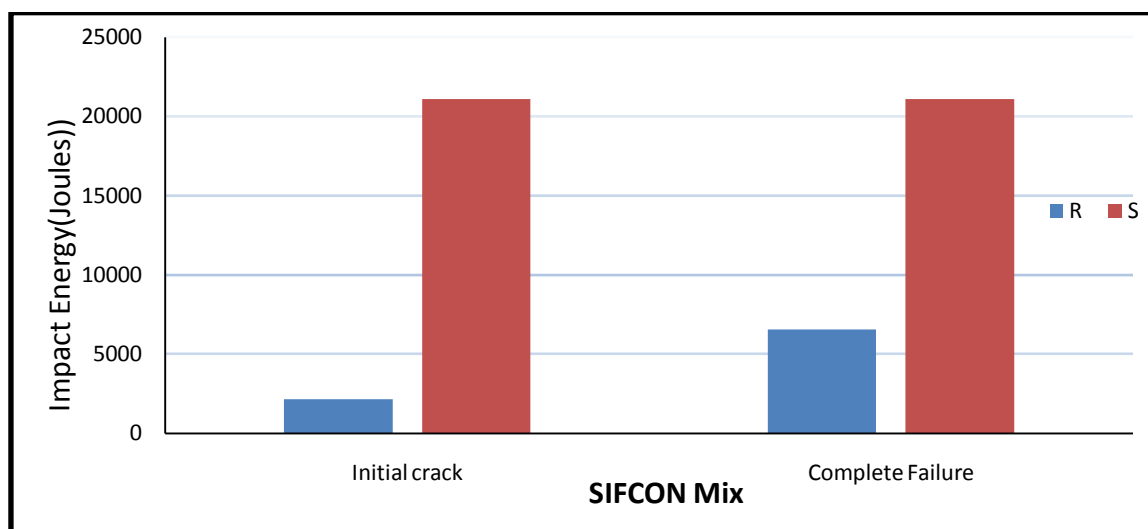


Fig. (8): Impact energy (joules)

## VII. CONCLUSION

From the experimental study of SIFCON, the following conclusion is drawn.

1. The (compressive, splitting, flexural) strength increased with ages for conventional mortar (reference) and SIFCON mix.
2. SIFCON show enhance in the (compressive, splitting, flexural) strength for all ages test when comparing with conventional mortar (reference).
3. a significant development in impact resistance for SIFCON mix at first crack and failure compared with the reference mix.
4. SIFCON mix exhibited the highest impact resistance.
5. The energy required for complete failure was which is increased by 9.97 times compared to the reference mix.

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# The Economic Development of Dam Construction Projects by Applying A Critical Chain Project Management

By Mohammad Javad Khosravi

*Islamic Azad University*

**Abstract-** The dam construction industry in Iran has always been considered as one of the country's most important industries due to the lack of rainfall. To accomplish this, we need to properly manage the dam construction process. Traditional algorithms, such as the Critical Paths Methods (CPM) and Program Evaluation and Review Technique (PERT) have been used since ancient times to plan and control most of the projects, including dam construction projects. With traditional methods of project management, a large percentage of time and resources are often lost due to reasons such as the lack of prioritization, student syndrome, and bad multi-tasking. The Critical Chain Project Management (CCPM) is a method for project planning, with emphasis on the resources needed to carry out the project. In this research, which was done on the Kahir reservoir, the CPM method was first used and then analyzed by CCPM method. Using resource dependency, identifying and embedding project buffers and leveling resources in this study reduced the implementation time of the project for 27 days

**Keywords:** kahir dam, buffers, resource leveling, CPM, CCPM.

**GJRE-E Classification:** FOR Code: 090599



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## I. INTRODUCTION

I ncreasing the population of cities and the people's desire to live in urban areas, reduce rainfall and imbalance in rainfall, has led the country's managers to increasingly control surface water management. There fore, managers considered building the dam as a strategic factor to deal with these problems. In fact, most developed countries consider the construction and implementation of numerous water resource development projects to accelerate the development of economic and social development. Dams are one of the most important development infrastructures with an emphasis on drinking water supply and increasing economic growth through irrigation of agricultural products, increased subsurface production and power generation, and flood control. Recognizing and evaluating these impacts in the process of sustainable rural development in relation to the situation of villages can be very useful and in order to exploit the capabilities created as a result of the construction of the dam.

In addition to the positive effects of these structures, we often see their negative impacts in various social, economic and environmental dimensions. Population displacement, migration, change in the type of economic activity, the spread of diseases and the disappearance of plant and animal species are among the negative effects of these structures. In recent years, extensive research has been carried out on the dam construction industry. Of the most important branches in the dam construction are flood control[1-4], water supply[5, 6], hydroelectric power generation[7], irrigation [8], reservoir operation [9-17], environmental and so on[18-24].

## II. RESEARCH METHODOLOGY

### a) Kahir Reservoir Dam

Kahir dam is a Roller-Compacted Concrete (RCC) type with a capacity of 314 million cubic meters (MCM) with the aim of irrigation and water supply since its launch in 2011. The lake has a length of 21 km, an overflow capacity of 8560 m<sup>3</sup>/sec, a reservoir area of 23 km<sup>2</sup>, and an overflow type is Ogee spillway without a valve. The length of the crest of the dam is 382.5 m, the width of the crown is 5 meters, the height is 54.5 meters and the volume of the reservoir is 314 million cubic meters in normal size.

Annual water supply of 20 MCM is carried out irrigation under pressure method, Chabahr and Konarak industries amount to 13 MCM, supply of drinking water from Chabahr and Konarak to 15 MCM, Rural water supply to 1400000 m<sup>3</sup>, and Artificial feeding on the bottom of the Kahir Dam is about 5 MCM of the general purpose of making the Kahir Reservoir. After using this dam, 2,450 hectares of downstream agricultural land will be used for irrigated irrigation systems. Other information is given below.

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*Location:* Sistan and Baluchestan province  
*City:* Chabahar  
*Dam site:* 5 km north of the Kahir village  
*Purpose:* Providing agricultural and drinking water  
*Adjustable water Annual:* 55 MCM  
*Basin:* Persian Gulf and Oman Sea  
*Sub-basin:* Baluchestan rivers  
*River name:* Kahir  
*Reservoir storage in normal:* 314 MCM  
*Executive:* Sistan and Balouchestan Ministry of Water



Figure 1: location of dam site

### III. METHODOLOGY

Floatation and leveling of resources in the project:

The following table is part of the Work-Breakdown Structure (WBS) of the Kahir dam

Table 1: Work-Breakdown Structure (WBS) of construction of the body of the Kahir dam using CPM method

Activity	Duration of activity (day)	Start (day)
Excavation of the body of dam	25	7
Guide wall reinforcement	68	16
Guide wall formatting execution	69	22
Guide wall concrete construction	67	25
Excavation of dam Cut off Wall	8	30
Drilling	515	32
Regularization and profiling of substrate for shell execution	12	35
Execution of plastic concrete in sealing wall	523	39
Filtration and horizontal drain	423	44
Implementation of RIP Rap	501	44
Preparation and execution of the shell of the first part	419	45
Execution of clay layers	412	45
Execution of filter and straight drainage	349	45
Execution of sealing wall	531	274

The following chart also shows the Gantt Chart of the CPM method of activity related to the dam body. The total of these activities is 799 days. The red color indicates the criticality of the activities. The resource

construction project (dam body), which is used by the CPM method to control the project.

chart used with the CPM method for the dam body section is given below. It is clear that this chart is before the leveling of resources.

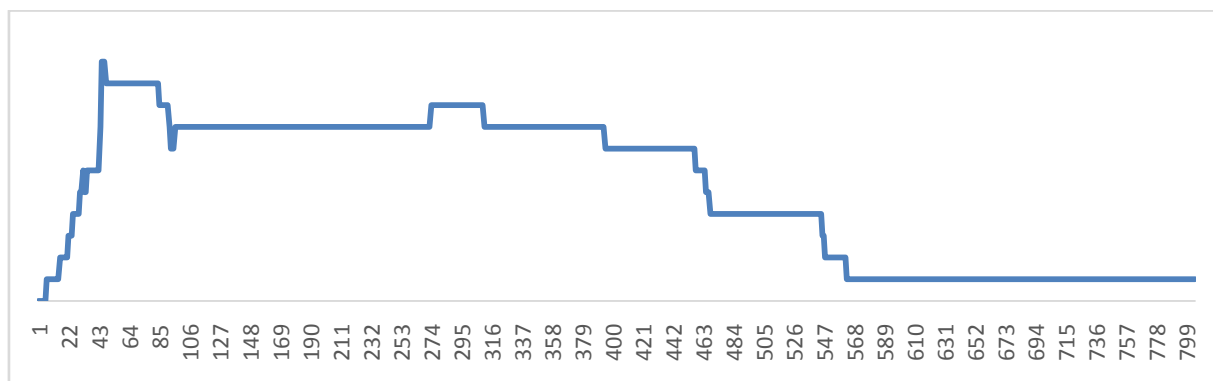


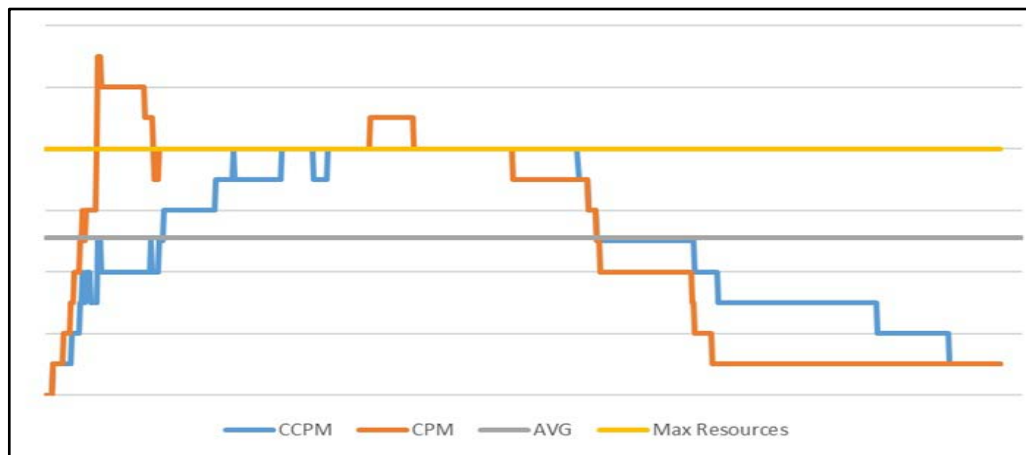
Figure 2: Resources used in the dam body through the CPM method before resources leveling

After applying the changes to the floats, we get the following results. (The origin of the starting day is shown in the table below as of August 22, 2012)

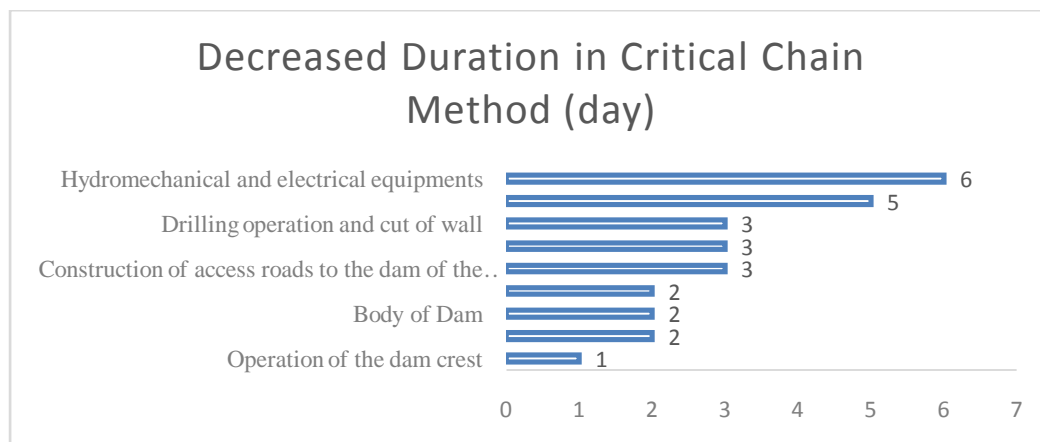
*Table 2:* Work-Breakdown Structure (WBS) of the construction of body in Kahir dam using CCPM method

Activity	Duration of activity (day)	Start (day)
Excavation of the body of dam	25	0
Guide wall reinforcement	68	15
Guide wall formatting execution	69	83
Guide wall concrete construction	67	152
Excavation of dam Cut off Wall	8	23
Drilling	515	25
Regularization and profiling of substrate for shell execution	12	28
Execution of plastic concrete in sealing wall	523	232
Filtration and horizontal drain	423	137
Implementation of RIP Rap	501	193
Preparation and execution of the shell of the first part	419	38
Execution of clay layers	412	38
Execution of filter and straight drainage	349	93
Execution of sealing wall	531	265

A comparison chart of the CPM and CCPM seen clearly, the CCPM method does not exceed the maximum amount of resources. method is presented in the following figure. As can be maximum amount of resources.



*Figure 3:* Resource chart used in the dam body using CCPM method after resource leveling



*Figure 4:* The decreased duration of activities in the CCPM method

The total duration of the project is 1348 days based on the CCPM method. This amount reduced the completion time of the project by 27 days to the planned CPM duration.

#### IV. RESULTS AND DISCUSSION

As shown in the figures below, taking into account the floats and slack in the activities, the activities move as far as possible to the extent that they allow the leveling of the maximum resources to be appropriate. These changes are available to reduce resources to reach available resources. The result of the time of these changes was to shift the time of some activities to the Finish to Start type. Most of the changes in the current example are from day 394 to day 452 and

from day 497 to day 764. We are seeing a decrease in resources in the 15th to 202th and 226th to 230th and 273th to 312th days of the project in order to flatten the resources. Most of the changes mentioned above are due to the shifting of the reinforcing operations, the formatting and execution of the guide wall, Execution of plastic concrete in cut off wall and the implementation of the horizontal drain filter. Due to the lack of flotation in the excavation of the body of the dam, the excavation of the dam's cut off wall and profiling of the substrate for the shell execution, as well as the preparation and implementation of the shell (in the first part) and the implementation of clay layers (Due to being in critical activities), there was no shifting in these cases.

Allocation of resources in CPM and CCPM Procedures

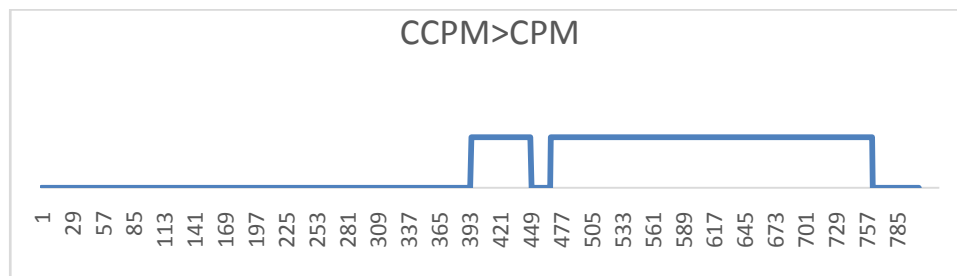


Figure 5: Comparison of the days when the sources of the CCPM method are higher than the CPM method

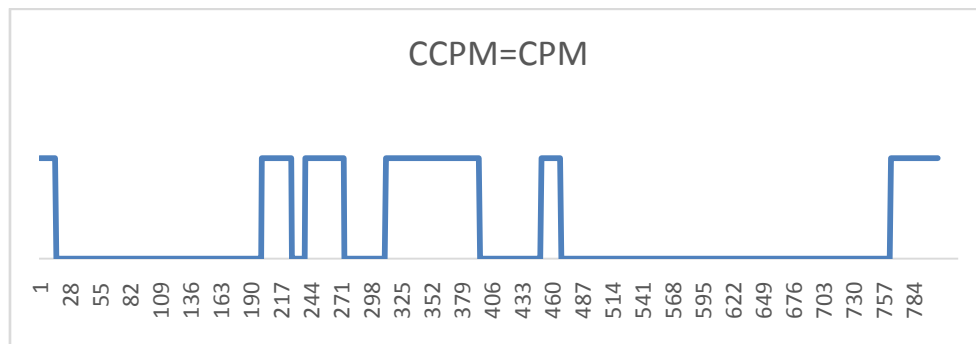


Figure 6: Comparison of the days when the sources of the CCPM method are equal to the CPM method

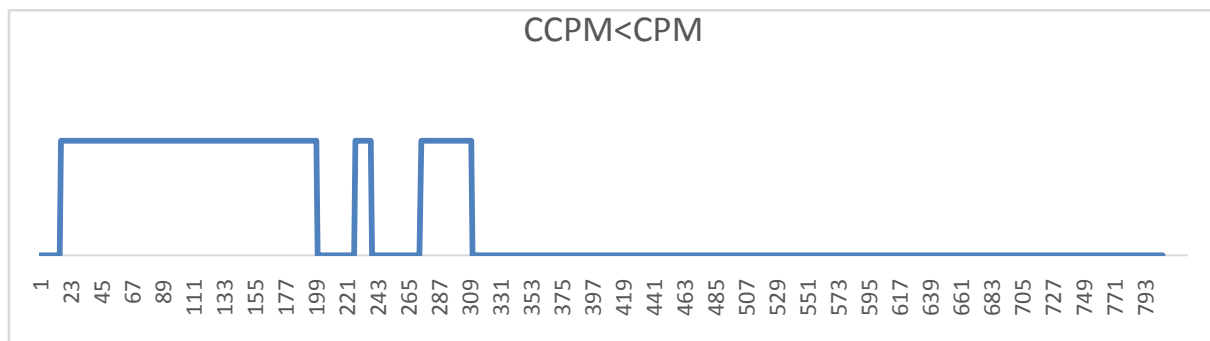


Figure 7: Comparison of days when resources of the CCPM method are less than CPM

#### V. ALLOCATION OF RESOURCES AND CPM METHOD

As indicated in the figures below, the amount of resources available in the CPM method at some time

intervals from the project is greater than the maximum amount of allocated resources. The resource constraints lead to the use of critical chain management method (CCPM) in project control. Therefore, in order to solve



this problem, the difference in resources needed for project management and control with the CPM method should be reduced to the maximum amount of available resources to zero.

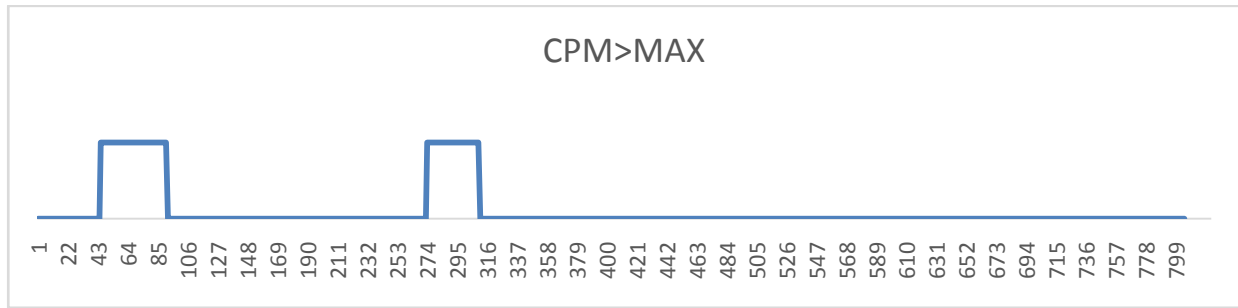


Figure 8: Comparison of days of the project where the resources of the CPM method are greater than the maximum amount of resources.

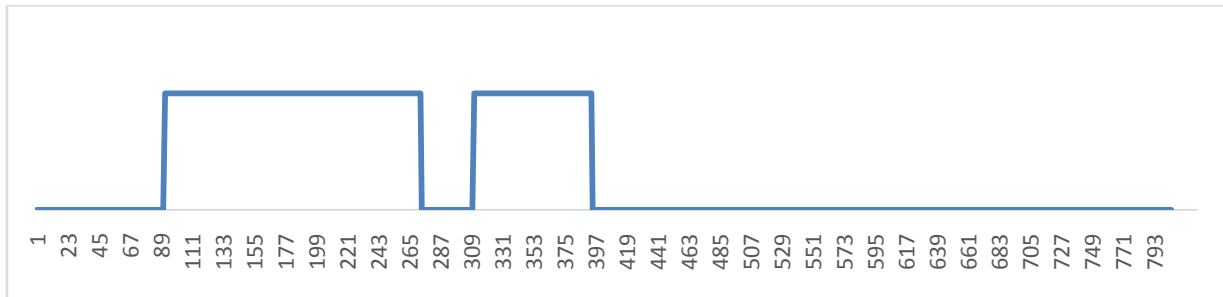


Figure 9: Comparison of days of the project, where resources of the CPM method are equal to the maximum amount of resources.

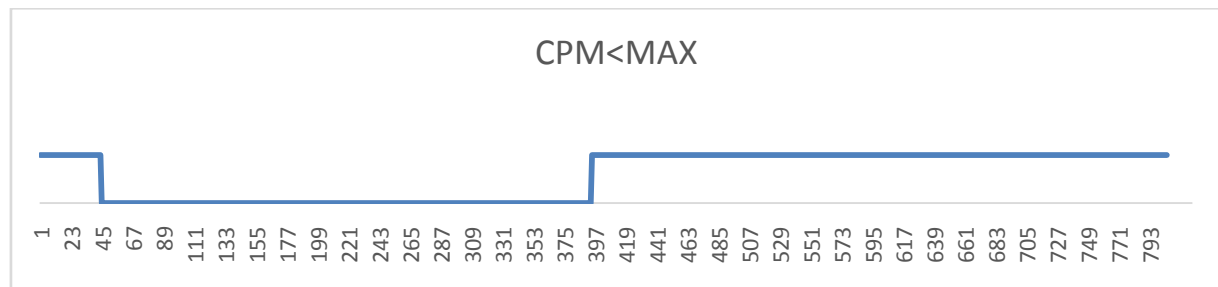


Figure 10: Comparison of days of the project where the resources of the CPM method are less than the maximum amount of resources.

## VI. ALLOCATION OF RESOURCES AND CPM METH

The efficiency of the CCPM method is clearly demonstrated due to the non-violation of maximum resources.

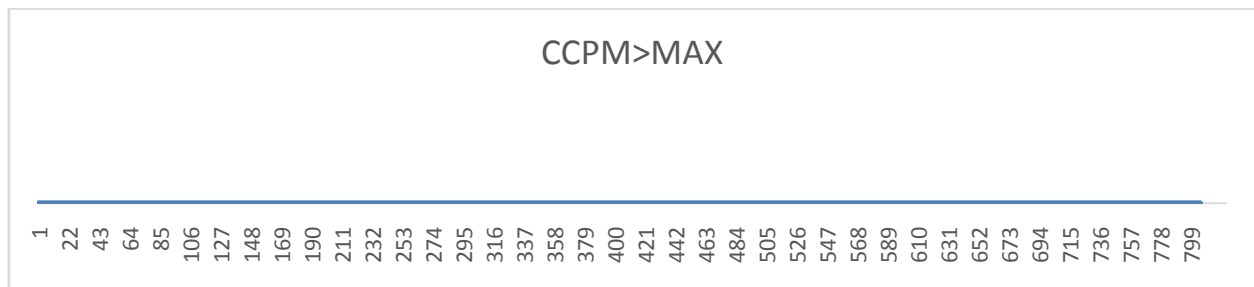


Figure 11: Comparison of days of the project where the resources of the CCPM method are greater than the maximum amount of resources.

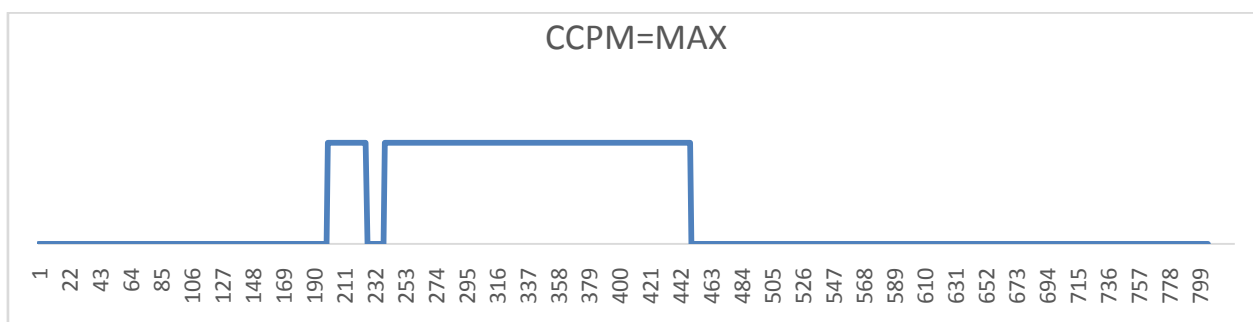


Figure 12: Comparison of days of the project where the sources of the CCPM method are equal to the maximum amount of resources.

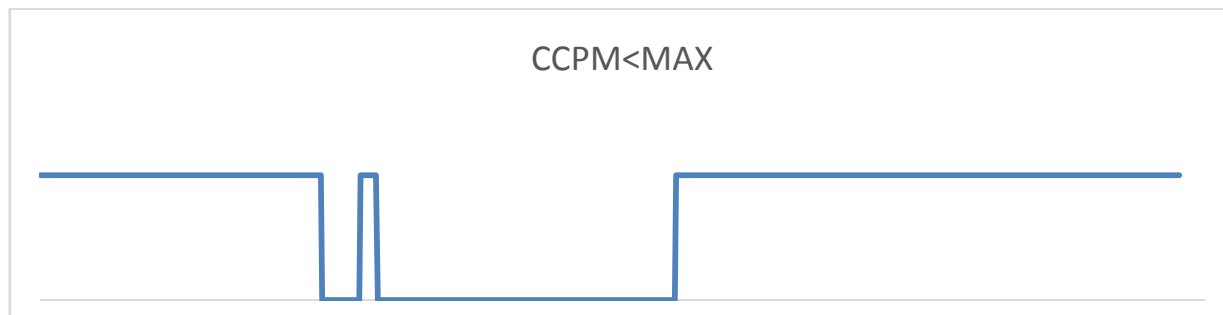


Figure 13: Comparison of days of the project where the resources of the CCPM method are less than the maximum amount of resources.

## VII. ECONOMIC ANALYSIS

In order to carry out the economic analysis (due to the reduction of 27 days of the project time) in the present project (using the critical chain method for the project of construction of the Kahir dam) the sum of the resulting benefits including employment income and income from operation were used. The direct benefits of this project were the value of agricultural income in the region, fish farming and hydropower production, and non-direct benefits included employment during the construction phase and operating period. Data used in the calculation and analysis below have been received from Sistan-Balouchestan Regional Water Organization and reliable sources.

*Part I: Calculation of the amount of proceeds from early utilization (27 days)*

Amount of proceeds from exploitation: 209880000000 Rials

Early operation ratio:  $7.397\% = 27/365$

As a result, the product of this percentage is equal to the amount of income equivalent to: 15525369863 Rials.

*Part II: Calculation of the amount of employment income*

The ratio of 7.397% is sufficient to multiply one year's income from work of 110 million Rials. Therefore, the amount of 8136987 Rials is also considered as 27-day earnings. The sum of the figures obtained is 15533506849 Rials, which is the total sum of the revenues.

## VIII. CONCLUSION

Construction of dam like other civil engineering activities will have positive and negative effects, especially in the long run. Of the most important positive effects of dam building on the region are the following: Increase in rural development, Increase in the value of arable land, Increased revenues through jobs (agricultural and non-agricultural), Increased employment. Also, with the construction of the dam, we see an increase in employment (falling unemployment) in the region. According to inflation and unemployment in the Philips theory, inflation in the region is also decreasing with increasing employment. As a result, we will see income growth, well-being, health and education in the region.

However, damage to ancient monuments (if any), damage to facilities within the study area (such as school, roads, water, electricity, and telecommunications), environmental impacts, high cost of resettlement are among the negative economic consequences of dam construction projects. It is important to consider the social issues and the sustainable development of the project and increase the amount of profit for the project.

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The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as “Institutional Board of Open Association of Research Society”-(IBOARS).

*The Institute will be entitled to following benefits:*



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The author fees of such paper may be waived off up to 40%.

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The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

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After nomination of your institution as “Institutional Fellow” and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.

The board can also take up the additional allied activities for betterment after our consultation.

### **The following entitlements are applicable to individual Fellows:**

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.



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- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in-depth understanding of the application of suitable techniques to a particular area of research practice.

## Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of “Difference of Opinion [if any]” among the Board members, our decision will be final and binding to everyone.

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## PREFERRED AUTHOR GUIDELINES

### **We accept the manuscript submissions in any standard (generic) format.**

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### ***Manuscript Style Instruction (Optional)***

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
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- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

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The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

- a) A title which should be relevant to the theme of the paper.
- b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
- c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
- d) An introduction, giving fundamental background objectives.
- e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
- f) Results which should be presented concisely by well-designed tables and figures.
- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

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- j) There should be brief acknowledgments.
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***It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.***

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### **Abstract**

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

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A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

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Numerical methods used should be transparent and, where appropriate, supported by references.

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Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

### **Formulas and equations**

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

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Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



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Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

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Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

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## TIPS FOR WRITING A GOOD QUALITY ENGINEERING RESEARCH PAPER

Techniques for writing a good quality engineering research paper:

**1. Choosing the topic:** In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

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**12. Know what you know:** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

**13. Use good grammar:** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

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**17. Never copy others' work:** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

**18. Go to seminars:** Attend seminars if the topic is relevant to your research area. Utilize all your resources.

**19. Refresh your mind after intervals:** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

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**22. Report concluded results:** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

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## INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

### Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

### Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

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This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

### General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

**To make a paper clear:** Adhere to recommended page limits.

### Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.





- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

#### **Title page:**

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

*Reason for writing the article—theory, overall issue, purpose.*

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

#### **Approach:**

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

#### **Introduction:**

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.



**Approach:**

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

**Procedures (methods and materials):**

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

**Materials:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

**Methods:**

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

**Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

**What to keep away from:**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.



**Approach:**

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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<b>Methods and Procedures</b>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<b>Result</b>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<b>Discussion</b>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<b>References</b>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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